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Port Isabel (GIWW) Channel Improvements at the Queen Isabella Causeway

Laguna Madre, Texas, Navigation Improvement Project

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Final report

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Abstract: Laguna Madre is located on the southern shore of the state of Texas. The Gulf Intracoastal Waterway (GIWW) passes under the Queen Isabella Causeway between Port Isabel and South Padre Island. In 2001, a tow struck the Queen Isabella Causeway collapsing a span of the bridge and resulting in the death of eight motorists. In response to that event, the U.S. Army Engineer District, Galveston, (SWG) was tasked with making channel improvements that would provide for safer navigation through the Queen Isabella Causeway. To assist SWG in evaluating alternatives for the proposed channel improvements, the U. S. Army Engineer Research and Development Center (ERDC) conducted a navigation study utilizing real-time ship simulation modeling. Model development and online testing occurred at the ERDC Waterways Experiment Station (WES) in Vicksburg, MS during the period from August 2005 to May 2007.

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Preface

This navigation study was performed at the U.S. Army Engineer Research and Development Center (ERDC), Ship/Tow Simulator Facility, located in the Coastal and Hydraulics Laboratory (CHL), ERDC, Vicksburg, MS, at the request of the U.S. Army Engineer District, Galveston (SWG).

It was conducted by Timothy W. Shelton of the Deep Draft Navigation Group, Navigation Branch, CHL. Assistance with pilot testing was given by Donna Derrick, Danny Marshall, and Peggy Van Norman. Testing was completed in May 2007, under the supervision of Thomas W. Richardson, Director, CHL.

Acknowledgment is made to George Alcala and Baldev Mann of SWG for cooperation and assistance. Special thanks are extended to Captain Raymond Butler of the Gulf Intracoastal Canal Association for help securing experienced tow captains to assist in testing.

COL Gary E. Johnston was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

Unit Conversion Factors

Multiply	By	To Obtain
feet	0.3048	meters
inches	0.0254	meters
knots	0.5144444	meters per second
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
tons (long) per cubic yard	1,328.939	kilograms per cubic meter
tons (2,000 pounds, mass)	907.1847	kilograms
tons (2,000 pounds, mass) per square foot	9,764.856	kilograms per square meter

1 Introduction

Background

Port Isabel is located on the southern shore of the state of Texas, on Laguna Madre, just inland from South Padre Island in close proximity to the United States border with Mexico (Figure 1). South of Port Isabel, the Gulf Intracoastal Waterway (GIWW) intersects the Brownsville Ship Channel forming a “Y” shaped navigation channel. The Queen Isabella Causeway Bridge connects Port Isabel to South Padre Island. Barge traffic on the GIWW must navigate through one of the bridge deck spans via a fendering system. Southbound traffic must turn sharply to the west immediately after clearing the bridge fenders in order to stay in the navigation channel. Northbound tow traffic is in the process of completing a northern turn when alignment with the opening in the fendering system is necessary. The details of the navigation channels for the area are shown in Figure 2.

The GIWW is an inland navigation channel that runs the length of the United States Gulf Coast. The portion of the GIWW in the vicinity of Port Isabel connects the Ports of Mansfield, Harlingen, Port Isabel, and Brownsville with points in more northern portions of Texas as well as Louisiana, Mississippi, Alabama, and Florida. The GIWW is maintained at 12-ft and basically 100-ft wide across the Laguna Madre. Tonnage along this segment of the GIWW averaged approximately 2,264,000 short tons from 1990 to 1999.

In September 2001, a four barge tow struck one of the Queen Isabella Causeway’s bridge piers and collapsed a 240-ft section of the bridge deck. This resulted in the death of eight motorists who were traversing the bridge and unable to stop prior to driving off the missing portion of the bridge deck and into Laguna Madre.

Purpose

In response to the catastrophic event of 2001, the Galveston District (SWG) is investigating whether a modification to the existing channel alignment is necessary. Two potential channel modifications in the form of wideners have been proposed if modification to the existing proves necessary. The U.S. Army Engineer Research and Development Center

(ERDC) conducted a navigation study utilizing real-time ship simulation modeling to evaluate the existing conditions and proposed modifications to the GIWW alignment with respect to the Queen Isabella Causeway should the existing conditions prove to be inadequate. Model development and online testing occurred at the ERDC Waterways Experiment Station in Vicksburg, MS during the period of August 2005 to May 2007.

2 Proposed Improvements

Originally, SWG proposed three channel re-alignments for the GIWW along the route from Corpus Christ to Brownsville through the Queen Isabella Causeway. In addition, SWG originally considered extending the existing fender system, an underwater berm to modify currents, and a breakwater to dissipate energy. The three original proposed realignments are shown in Figure 3. However, based on industry input and discussions between ERDC and SWG, all alternatives were abandoned in favor of an evaluation of the existing conditions. This evaluation, discussed in section 5 of this report, was used to discern recommendations regarding channel modifications via bend wideners.

3 Reconnaissance Trip

The reconnaissance trip for the Port Isabel study was conducted on April 28, 2005. The purpose of the trip was to ride tows traversing the GIWW through the Queen Isabella Causeway. In addition, ERDC representatives planned to take digital photographs and video, which would be used for simulation model development. Tow traffic volumes were minimal during the trip and the only tow that transited the reach in question passed underneath the bridge at night, making it impossible to collect digital photographs and video. Therefore, Kirby Corporation provided a small skiff and boat operator that was used to go out and traverse the reach. Digital photographs were taken from the skiff and used for simulation model development. Additional photos were taken from piers extending into Laguna Madre from Port Isabel to ensure model quality. A photograph of the bridge span and fender system taken during the reconnaissance trip is shown in Figure 4.

4 Database Development

Currents for the existing channels were calculated at ERDC using the TABS-MD suite of numerical models. Current data for both flood and ebb tidal currents for both a normal spring tide and a storm condition were extracted and converted into the format required by the ERDC Ship/Tow Simulator for both a normal tide range and a storm tide range.

Several tow models were used for the Port Isabel Navigation Study. The tow models, previously developed by Designers & Planners, included:

- Pusher Tow, two loaded 675-x54-x9-ft
- Pusher Tow, four loaded 1156-x54-x10-ft
- Pusher Tow, one loaded 357-x54-x9-ft
- Six Pack, 655-x70-x9-ft
- Pusher Tow, one empty 368-x54-x4-ft

The visual scene was constructed using photos taken during the reconnaissance trip and encompassed the reach from the “Y” connecting the GIWW to the Brownsville Ship Channel through the Queen Isabella Causeway and out into Laguna Madre. Port Isabel and portions of South Padre Island are both visible in the visual scene. In addition to land features, the visual scene contains all Aids-to-Navigation (ATONS) present in the exiting configurations. Figure 5 shows the approach to the Queen Isabella Causeway as it appears in the visual scene.

The Electronic Chart Display and Information System (ECDIS) was modified to reflect proposed changes to the channel footprints. Figure 6 shows an ECDIS chart modified to reflect changes made to the ATONS and channel along the approach to the Queen Isabella Causeway.

5 Analysis of Existing Conditions

Based on a visual analysis by ERDC and conversations with the towing industry, SWG and ERDC agreed that a week of “pre-testing” should be undertaken in order to analyze the existing navigation conditions along the approach to the Queen Isabella Causeway. The purpose of the pre-testing was to both validate the existing conditions and to determine if testing of some of the alternatives originally proposed by SWG could be eliminated. This existing conditions analysis was conducted using real-time tow simulation exercises conducted at the ERDC Ship/Tow facility in Vicksburg, MS.

The simulations were conducted June 12 – 30 using three tow captains from various towing companies. Figure 7 shows one of the tow captains operating the simulator during this effort. Results from these simulations are shown on plates 1 – 20.

Most of the runs passed safely through the bridge span. However, a few times the flotilla came in contact with the bridge’s eastern fender. One observation seen in several of the runs is that the tows tend to favor the outside of the bend while aligning for the bridge approach. One of SWG’s proposed alternatives is a bend widener in the approach channel as shown in Figure 8. Conversations with the tow captains during this analysis indicated that any problems aligning with the bridge could be resolved with a bend widener on the east side of the channel.

The results of this effort were discussed with Captain Raymond Butler, Executive Director, Gulf Intracoastal Canal Association (GICA). Capt. Butler concurred with the conclusions reached by ERDC concerning the bend widener on the east side of the bridge approach channel. Based on the results of the existing conditions analysis and the aforementioned discussions, the ERDC recommended that the remainder of the study should focus on the widening of the outside of the bend on the southern approach to the Queen Isabella Causeway. ERDC further recommended that all other alternatives as discussed in section 2 of this report be eliminated from further testing. Two alternative bend widener plans were developed as follows:

- Plan 1 – 112.5-ft bend widener with tie-in to GIWW at the southern approach, as shown in Figure 9
- Plan 2 – 60-ft bend widener with tie-in to GIWW at southern approach, as shown in Figure 10

6 Results

Testing of Plan 1 and Plan 2 was conducted from April 26 – May 1, 2007 at the ERDC Ship/Tow Simulator facility in Vicksburg, MS. Four tow captains familiar with the reach of GIWW through the Queen Isabella Causeway participated in the testing program. After each run, the tow captain was given a chance to provide written comments concerning the simulation. Based on the recommendations of the tow captains and indications derived from the track plots recorded during existing conditions analysis, only two vessels were used during testing of Plans 1 and 2. The two vessels used were:

- Six pack, 655-x79-x9-ft
- Pusher tow, two empty side by side, 368-x108-x4-ft

Results are presented in the form of composite track plots. Track plots are categorized by plan, vessel, direction of motion, and direction of tidal currents. Results will be presented by plan. All runs were conducted with a 20-knot southeast wind, the predominate worst-case wind for the location and alignment.

Plan 1

Plates 21 and 22 show the composite track plots for Plan 1, two empty barge tow, eastbound, under ebb and storm ebb tides, respectively. Both composites show that the tow exited the channel on the eastern side during the approach to the bridge span. Plates 23 and 24 show the composite track plots for Plan 1, two empty barge tow, eastbound, under flood and storm flood tides, respectively. Again, both composites show that the tow exited the channel along the eastern side of the channel during the approach to the bridge span. Plates 25 and 26 show the composite track plots for Plan 1, six pack tow, eastbound, under ebb and storm ebb tides, respectively. Under ebb tide conditions, the tow exited the channel on the eastern side during the approach to the bridge span. However, under storm ebb tide, the tow remained in the channel throughout the runs. Plates 27 and 28 show the composite track plots for Plan 1, six pack, eastbound, under flood and storm flood tides, respectively. During flood tide conditions, no tows exited the channel.

However, during storm flood tides, one run shows a significant channel exit while the remaining simulations stayed in the channel throughout the approach. Plates 29 and 30 show the composite track plots for Plan 1, tow empty barge tow, westbound, under ebb and storm ebb tides, respectively. Both composites indicate that the vessel left the channel in the turn south of the bridge. Plates 31 and 32 show the composite track plots for Plan 1, two empty barge tow, westbound, under flood and storm flood tides, respectively. Both track plots show that the tows left the channel south of the bridge on the eastern side of the channel. Plates 33 and 34 show the composite track plots for Plan 1, six pack tow, westbound, under ebb and storm ebb tides, respectively. Both track plots show little, if any, breach of the channel lines during the transit. Plates 35 and 36 show the composite track plots for Plan 1, six pack tow, westbound, under flood and storm flood tides, respectively.

Both track plots show some exiting of the channel south of the bridge along the eastern side of the channel. It should be noted that the tow captains did not indicate having any difficulty with any of the scenarios tested under the Plan 1 configuration. However, in almost all of the composite track plots, the tow left the buoyed channel at some point during the transit. It is likely that due to the pilots' experience with the difficulty of this turn, they significantly favored the eastern side of the channel, regardless of the width of the widener, based on the fact that in the existing conditions it is critical that the tow "hug" the eastern side of the channel in order to successfully navigation the bridge span. Therefore, the results of the simulation could be highly conservative.

Plan 2

Since results from Plan 1 indicated little if any difference between difficulty of navigation with respect to storm current and normal currents, and since the storm currents have higher magnitudes and similar directions to the spring tide currents, simulation of the normal spring tide currents was eliminated from Plan 2 testing.

Plates 37 and 38 show the composite track plots for Plan 2, two empty barge tow, eastbound, under storm ebb and storm flood tides, respectively. The composites show results similar to those in Plan 1 with channel breach occurring in both ebb and flood tides south of the bridge along the eastern side of the channel. Plates 39 and 40 show the composite track plots for Plan 2, six pack tow, eastbound, under storm ebb and storm flood tides,

respectively. Again, results were similar to those in Plan 1 with channel breach occurring significantly under ebb tide and not at all under flood tide conditions. Plates 41 and 42 show the composite track plots for Plan 2, two empty barge tow, westbound, under storm ebb and storm flood tides, respectively. Again, the track plots show that the tow left the channel significantly under ebb tides and not at all under flood tides. Plates 43 and 44 show the composite track plots for Plan 2, six pack tow, westbound, under storm ebb and storm flood tides, respectively. In both cases, the tow approached the channel lines south of the bridge on the eastern side of the channel and breached the channel only slightly, if any.

7 Recommendations

The results of the testing program indicate both the proposed Plan 1 and Plan 2 channel improvements provide some relief for the navigation difficulties along the approach to the Queen Isabella Causeway. In both Plan 1 and Plan 2, the tow captains were able to navigate through the bridge without impacting any of the fender system components. However, in both plans, the tows left the channel on the eastern side of the channel south of the bridge on both eastbound and westbound runs, under both ebb and flood tides. One item of interest is that when the Plan 2 simulations are overlain on the Plan 1 channel limits, instances of channel breach are few. Therefore, it seems that the pilots are favoring the eastern side of the approach channel based on their experience. This is due to the fact that “hugging” the eastern side is essential under the existing conditions in order to safely navigate the bridge. “Hugging” the eastern side of the channel is based upon what the captains are used to doing, rather than a deficiency in Plan 1. Therefore, based on the simulation results and pilot input, the following recommendations are made for channel improvements for the southern approach to the Queen Isabella Causeway:

- The Plan 2 bend widener is not recommended as it does not appear to provide sufficient width for tows to stay inside the channel limits and successfully navigate the bridge.
- The Plan 1 bend widener appears to provide enough width for tows to stay inside the channel limits and successfully navigate the bridge. While the Plan 1 simulations indicated that the tows repetitively left the channel limits, the Plan 2 runs indicate that the Plan 1 bend widener would likely be successful. In other words, the Plan 1 bend widener appears to provide enough room, but the captains did not take advantage of it. Plates 45 and 46 show the Plan 2 tow tracks imposed on the Plan 1 channel, indicating that the tows can safely navigate the bend with the Plan 1 bend widener.
- To ensure the bend widener provides sufficient width to remain in the channel and properly align with and navigate the bridge, the ERDC recommends providing a factor-of-safety to the Plan 1 bend widener by increasing its width from the proposed 112.5-ft width to 125-ft. This

additional width would have provided acceptable width to allow nearly all of the simulations to remain in the channel and successfully align with and navigate the bridge. Plates 46 and 47 show composites of all runs imposed on the recommended 125-ft bend widener. It is not necessary to conduct additional simulations for the 125 ft widener.

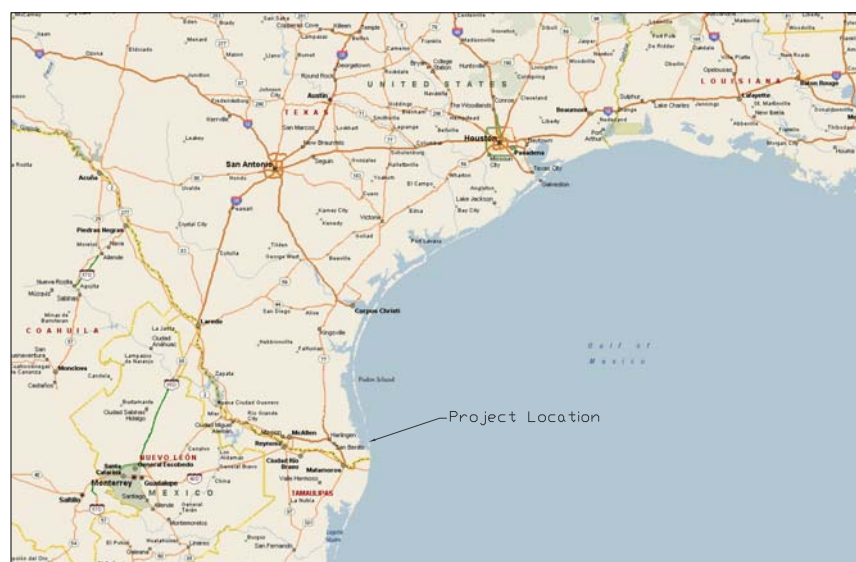


Figure 1. Project Location map.

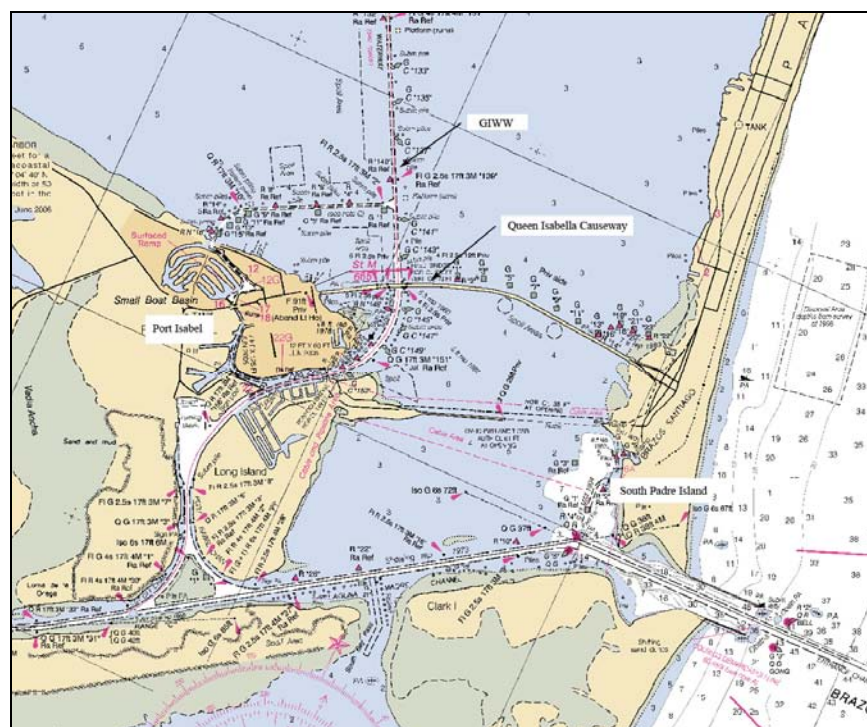


Figure 2. Layout of Navigation Channels.

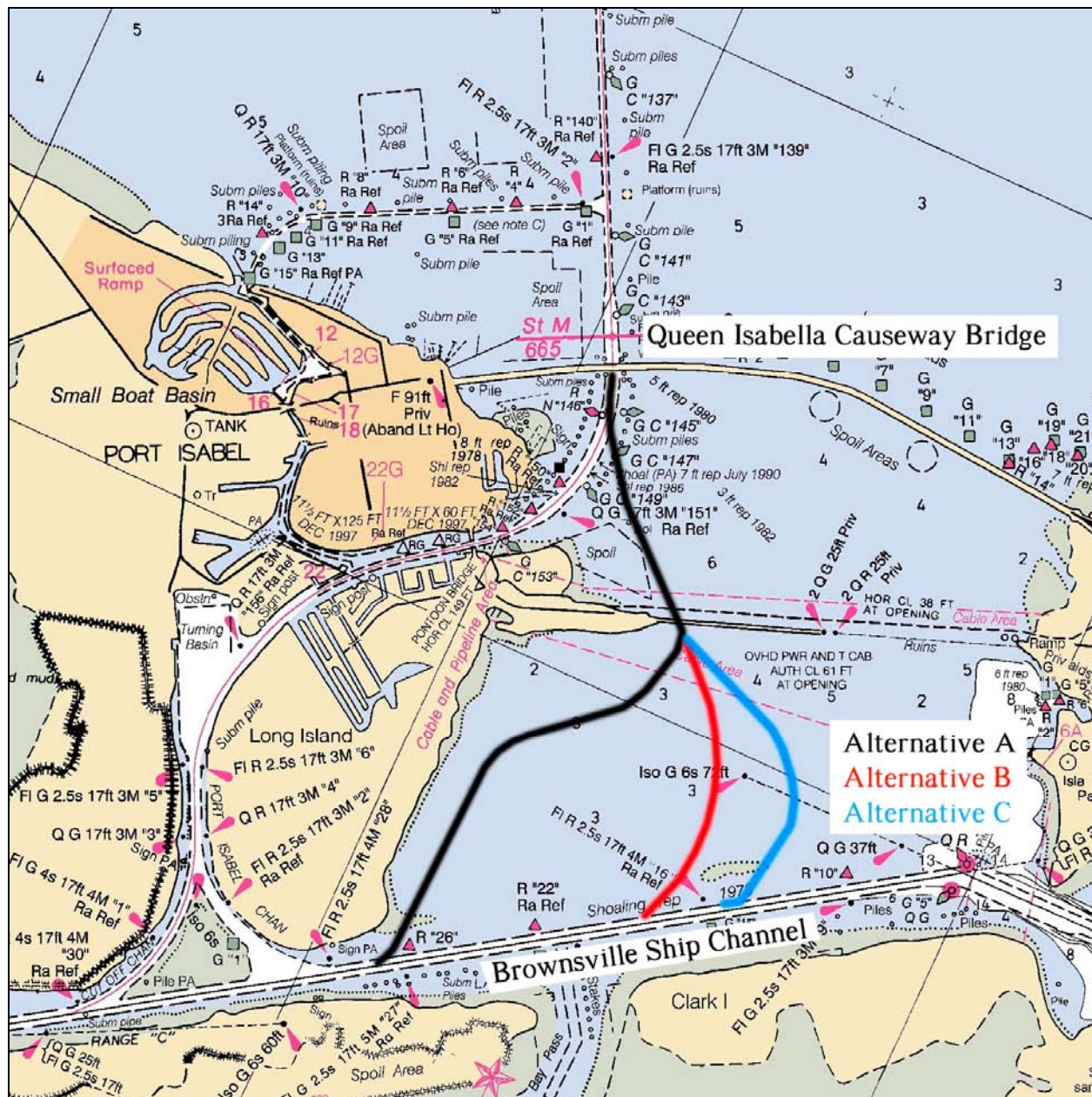


Figure 3. Originally proposed alternative improvements.



Figure 4. Queen Isabella Causeway and fender system.



Figure 5. Visual scene of approach to Queen Isabella Causeway.

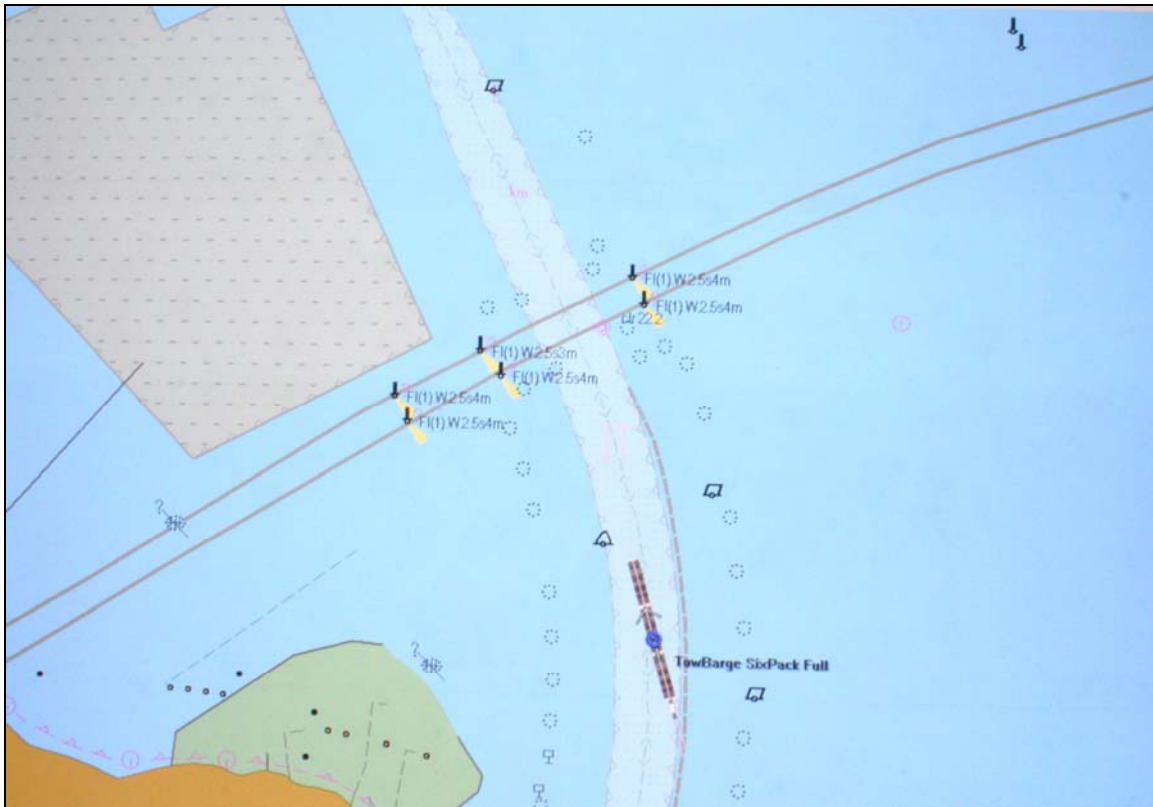


Figure 6. Modified ECDIS showing bend widener.



Figure 7. Tow captains approaching the swing bridge during existing conditions analysis.

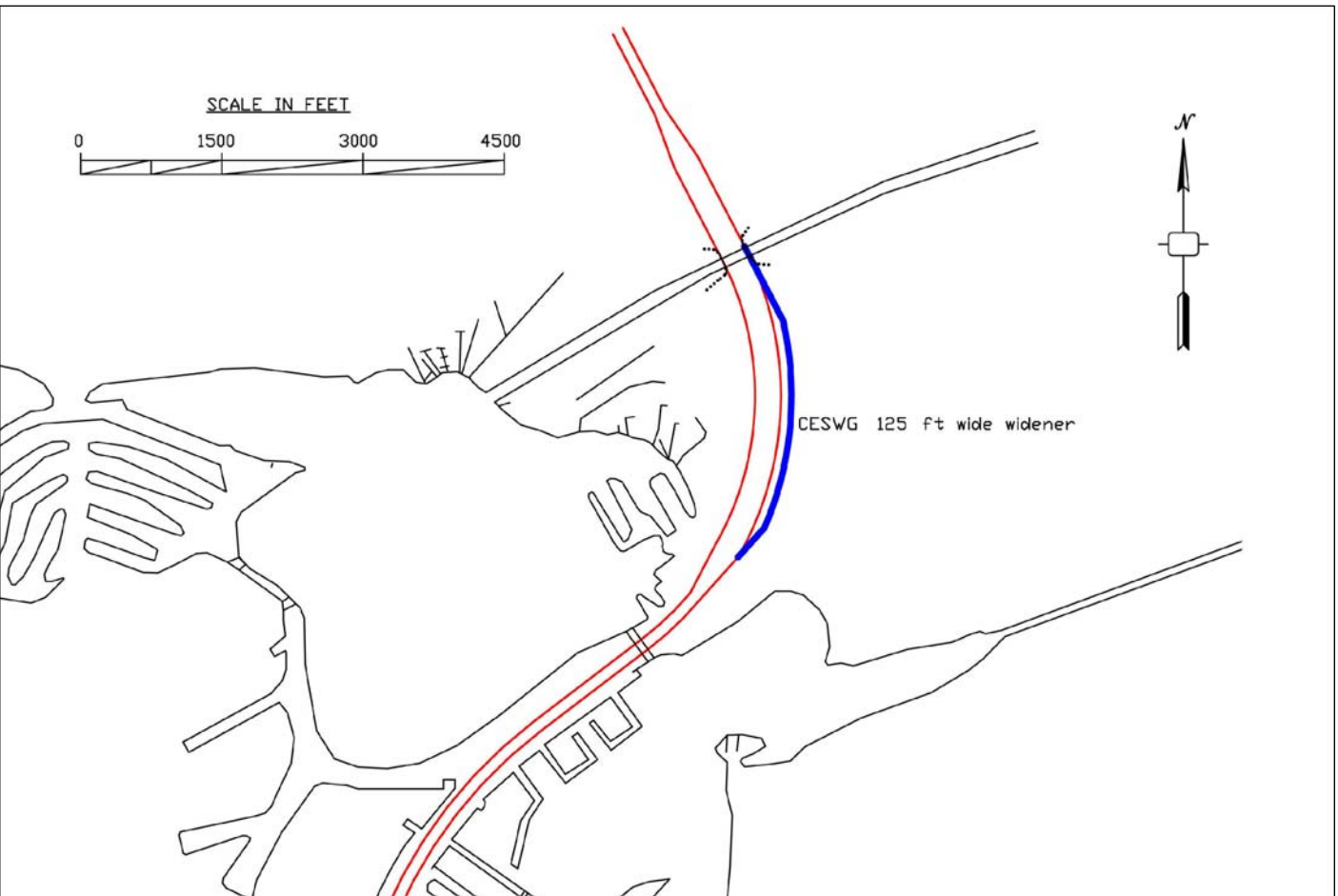


Figure 8. CESWG Widener.

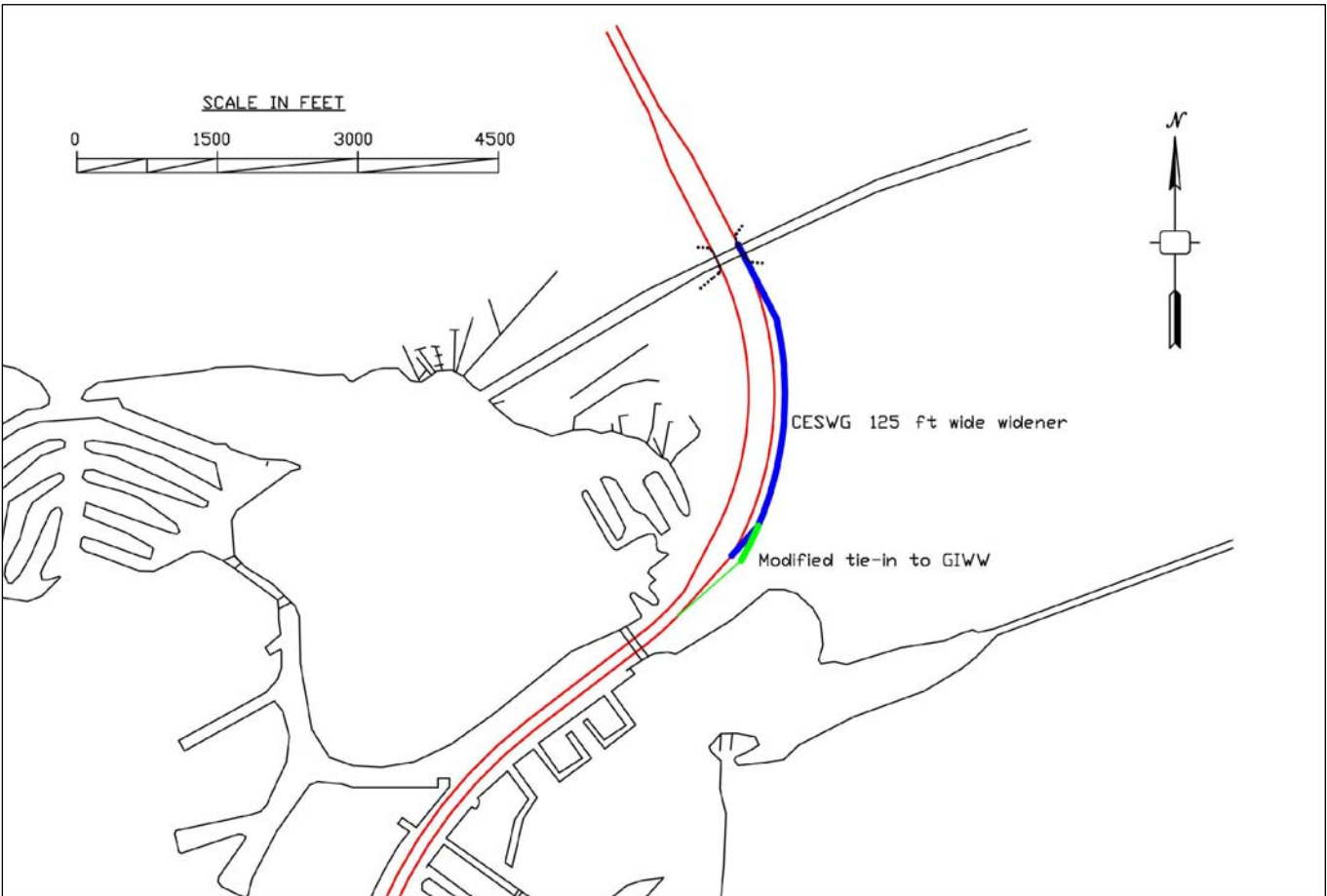


Figure 9. Modified Widener

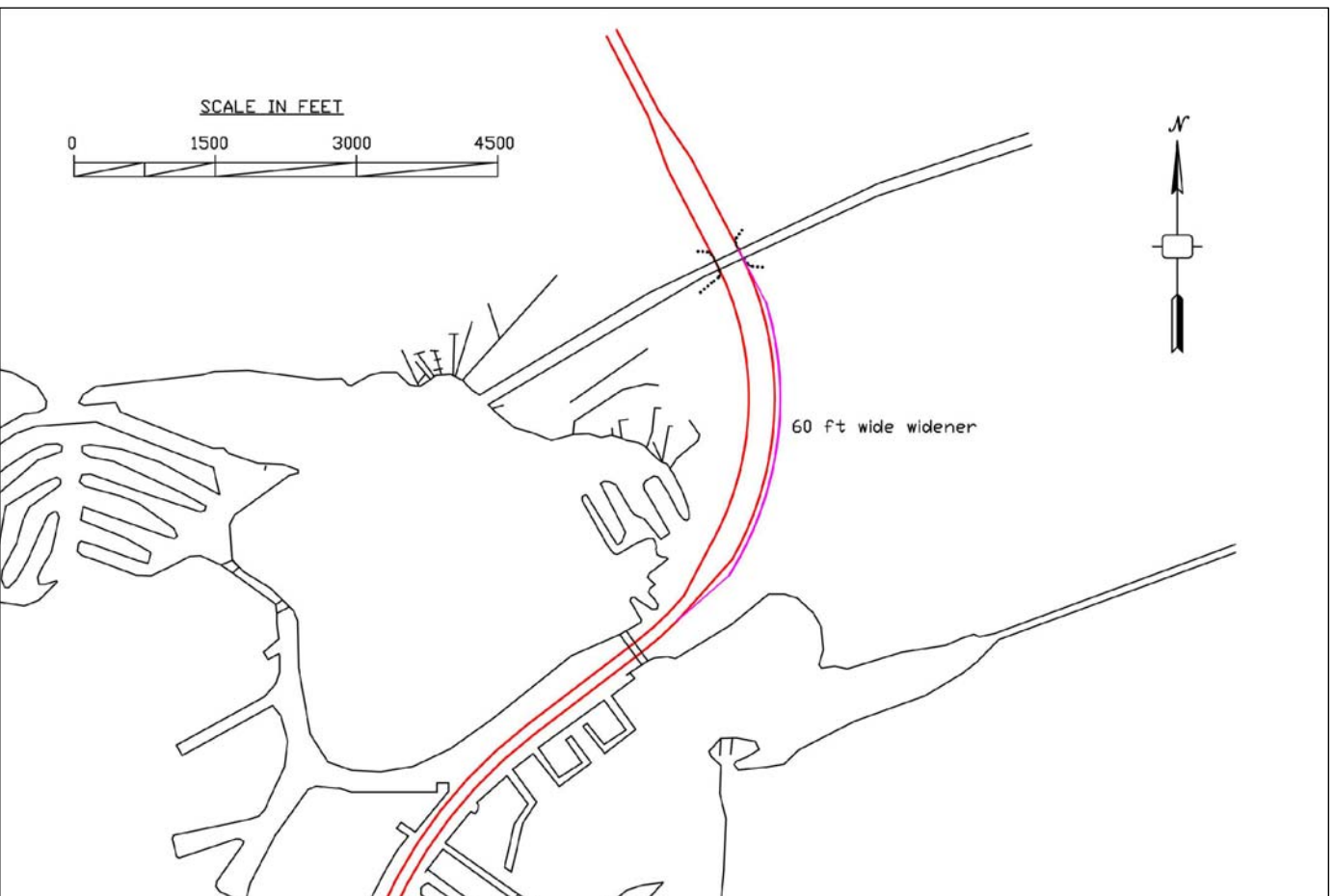


Figure 10. 60 FT. Widener.

Appendix A: Plates 1 – 44

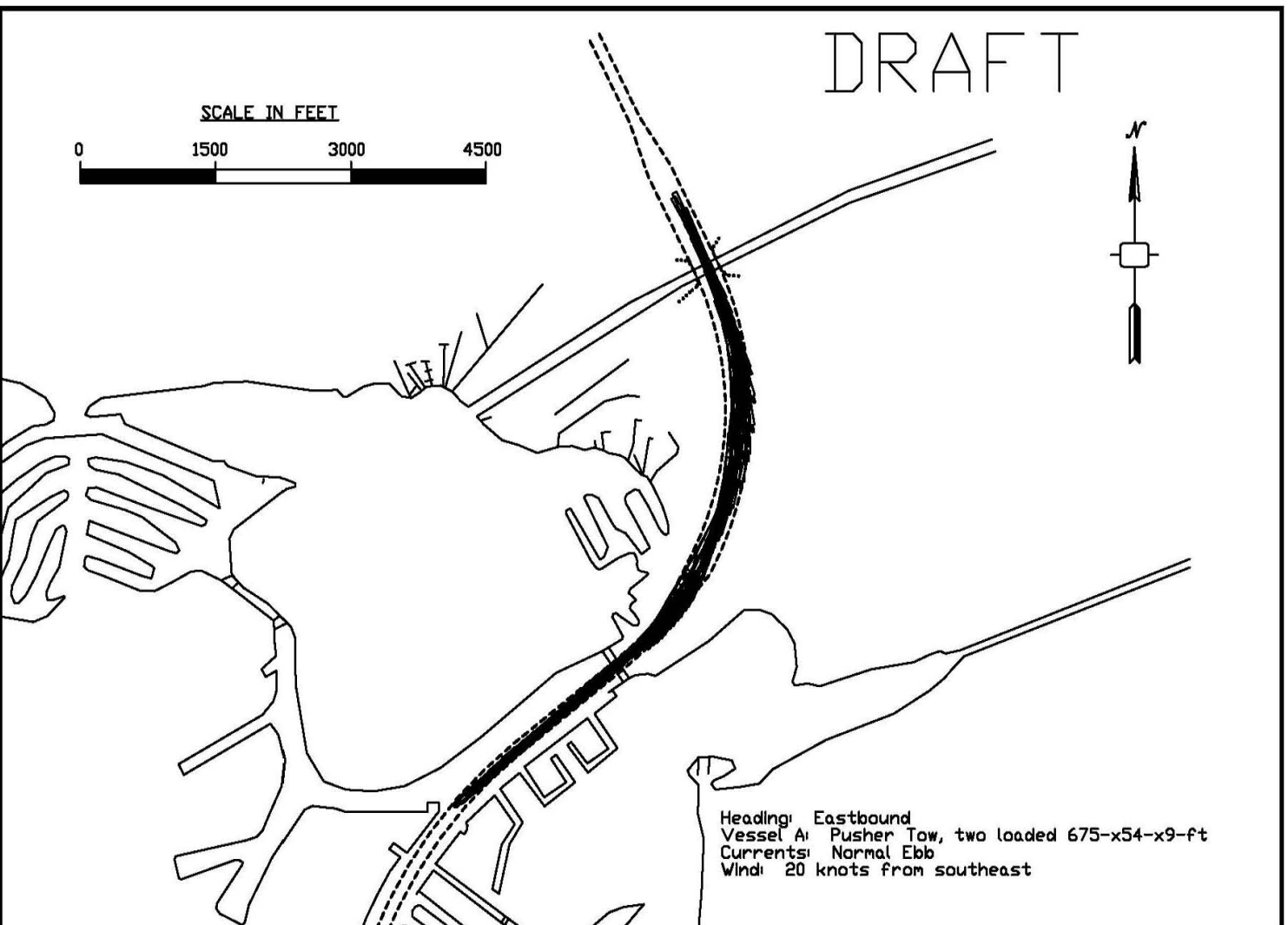


Plate 1

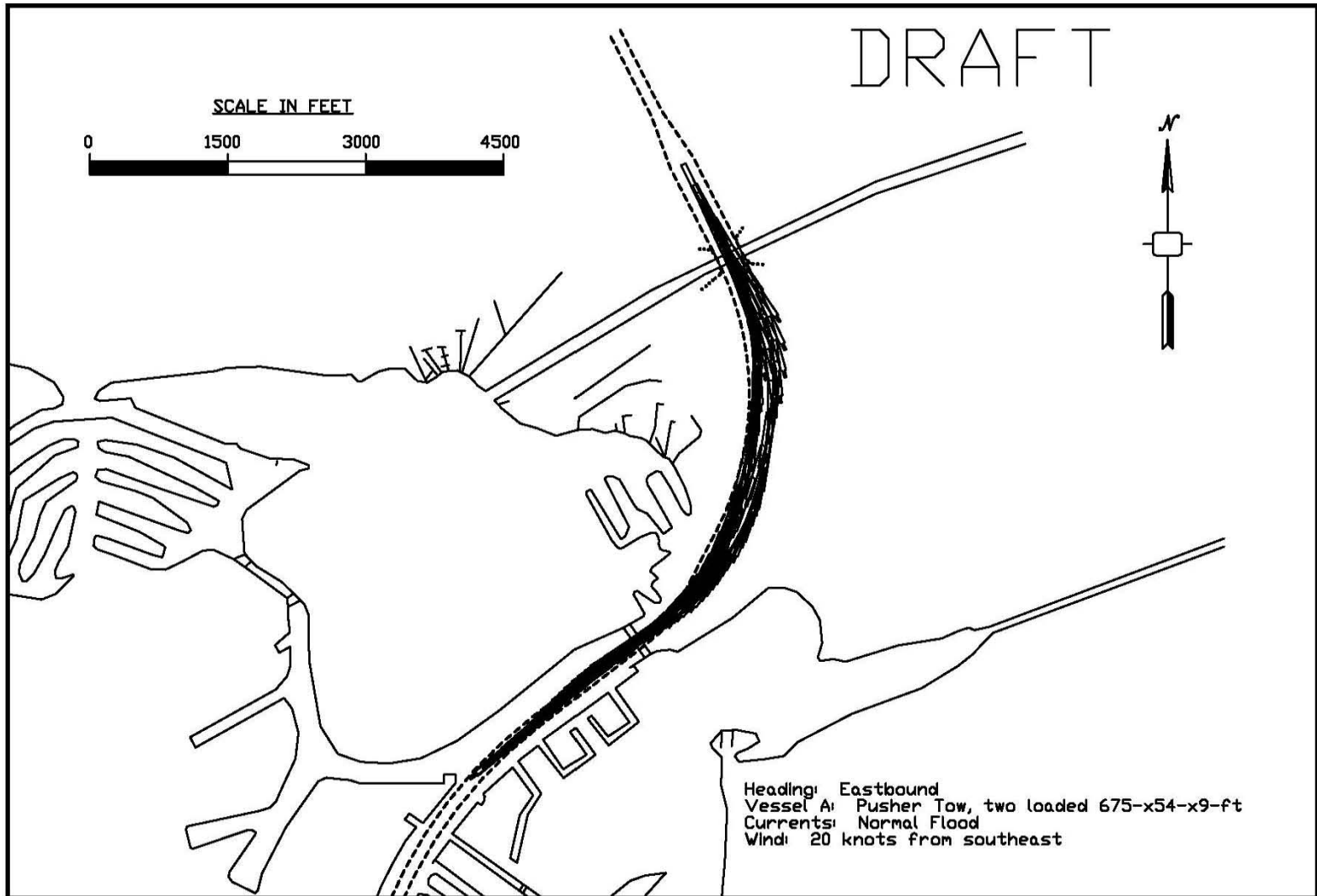


Plate 2

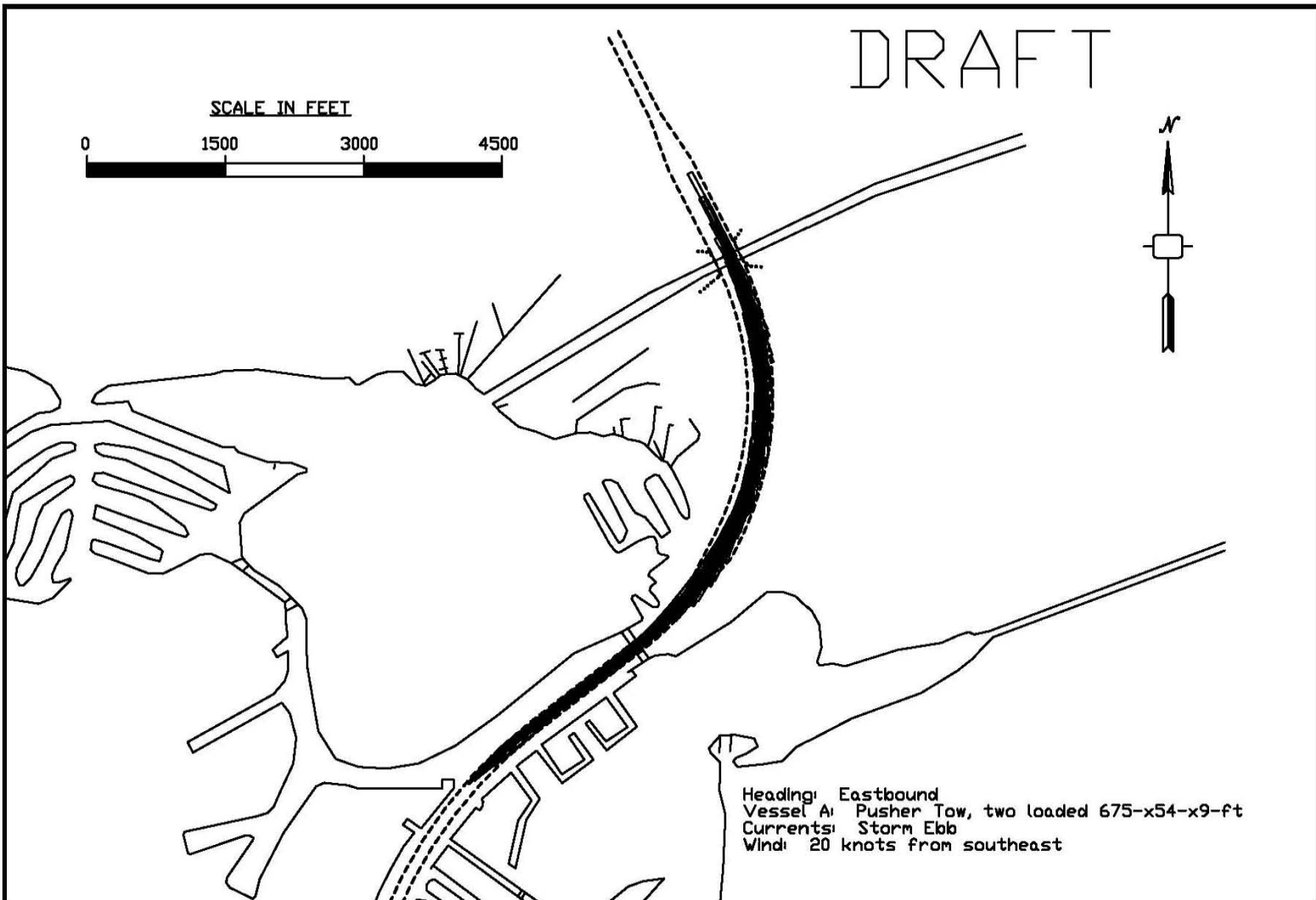


Plate 3

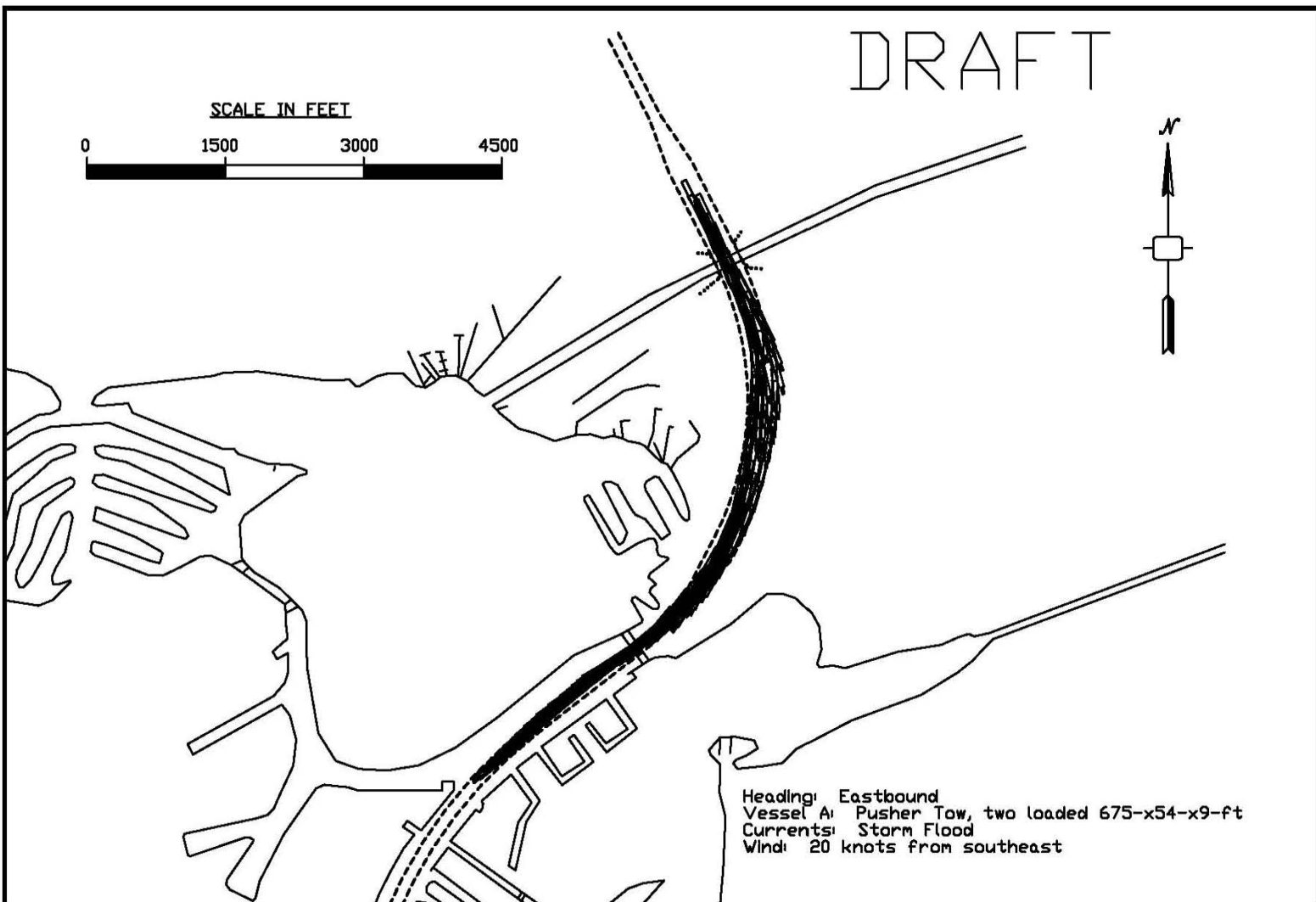
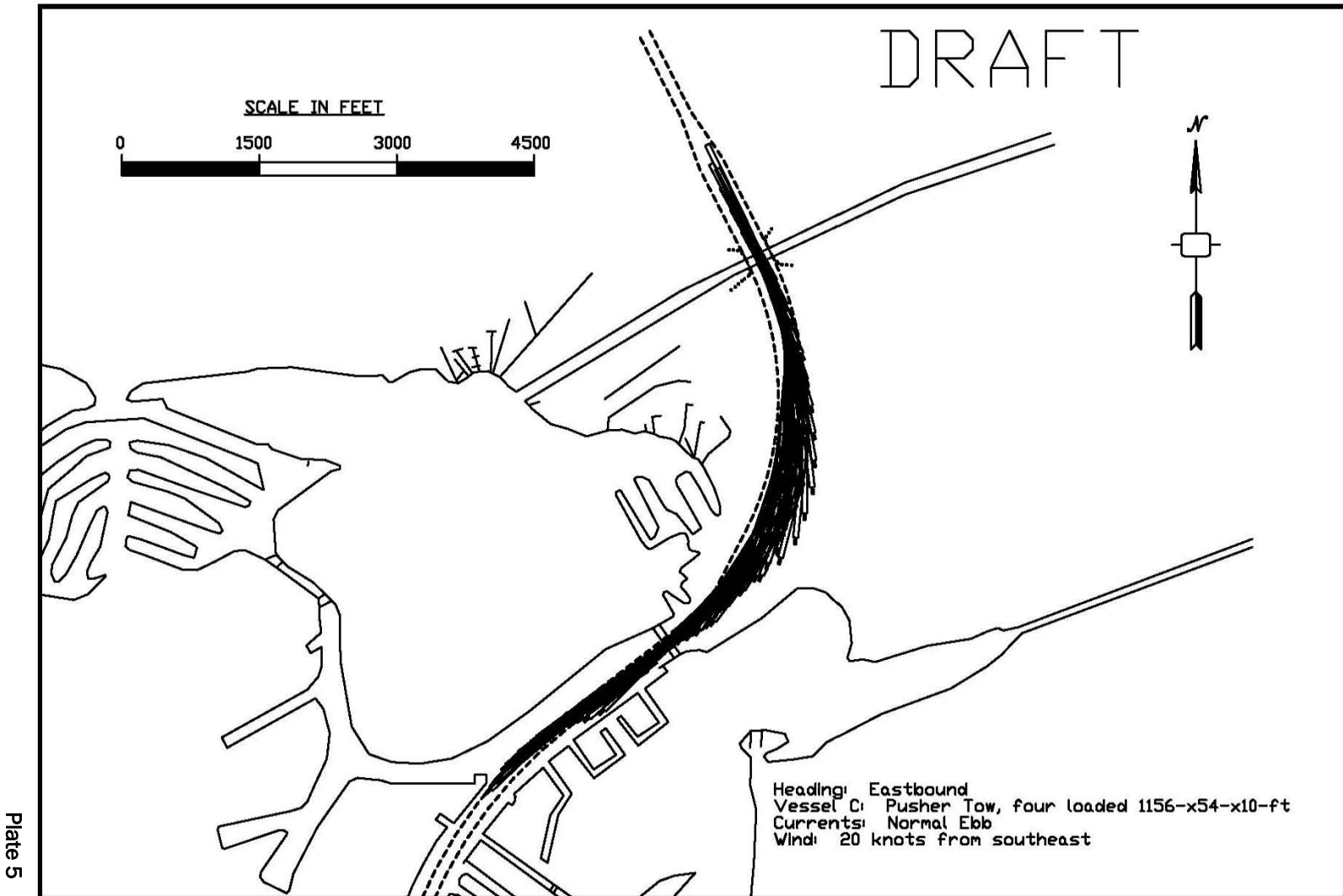
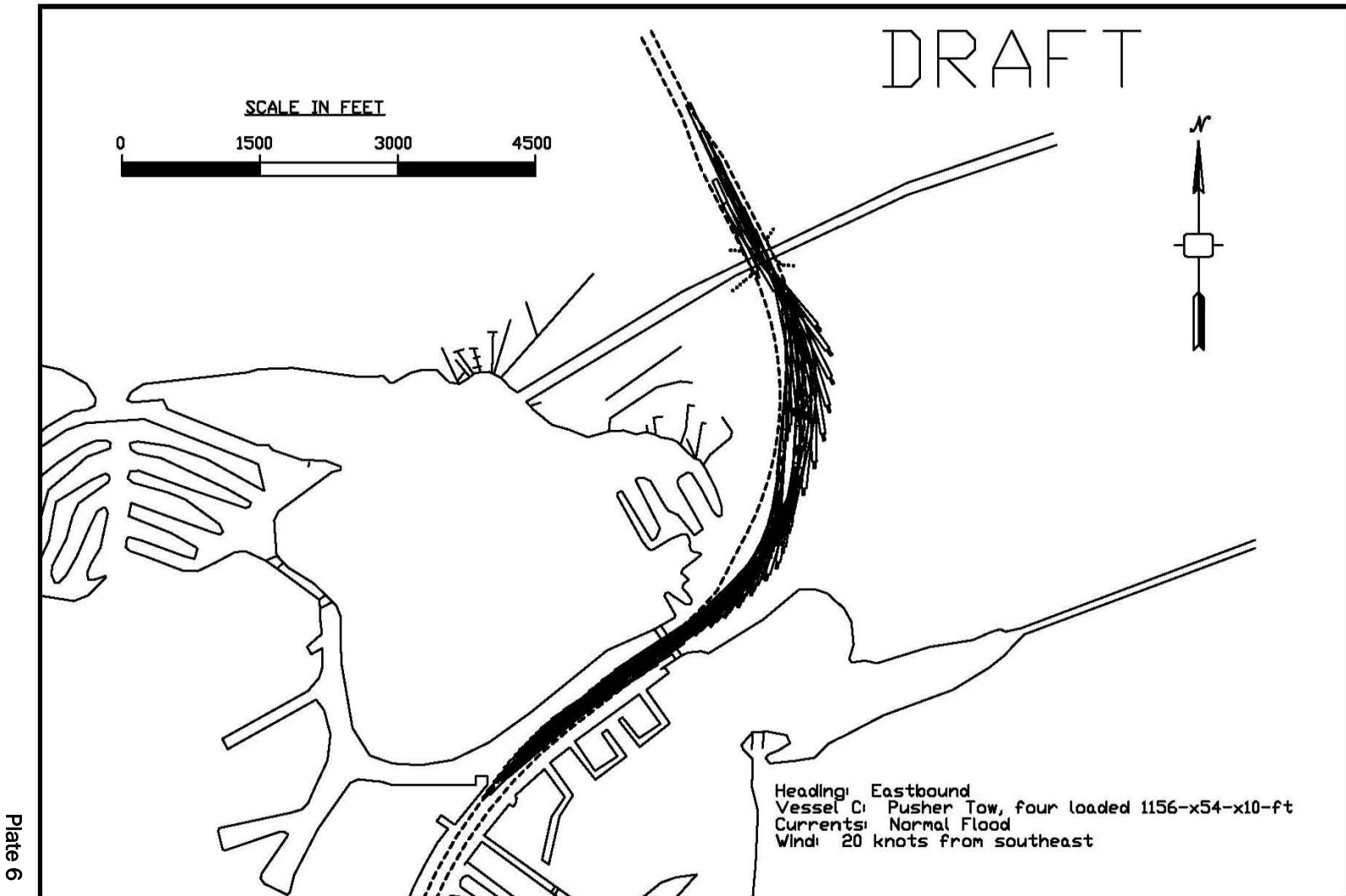


Plate 4





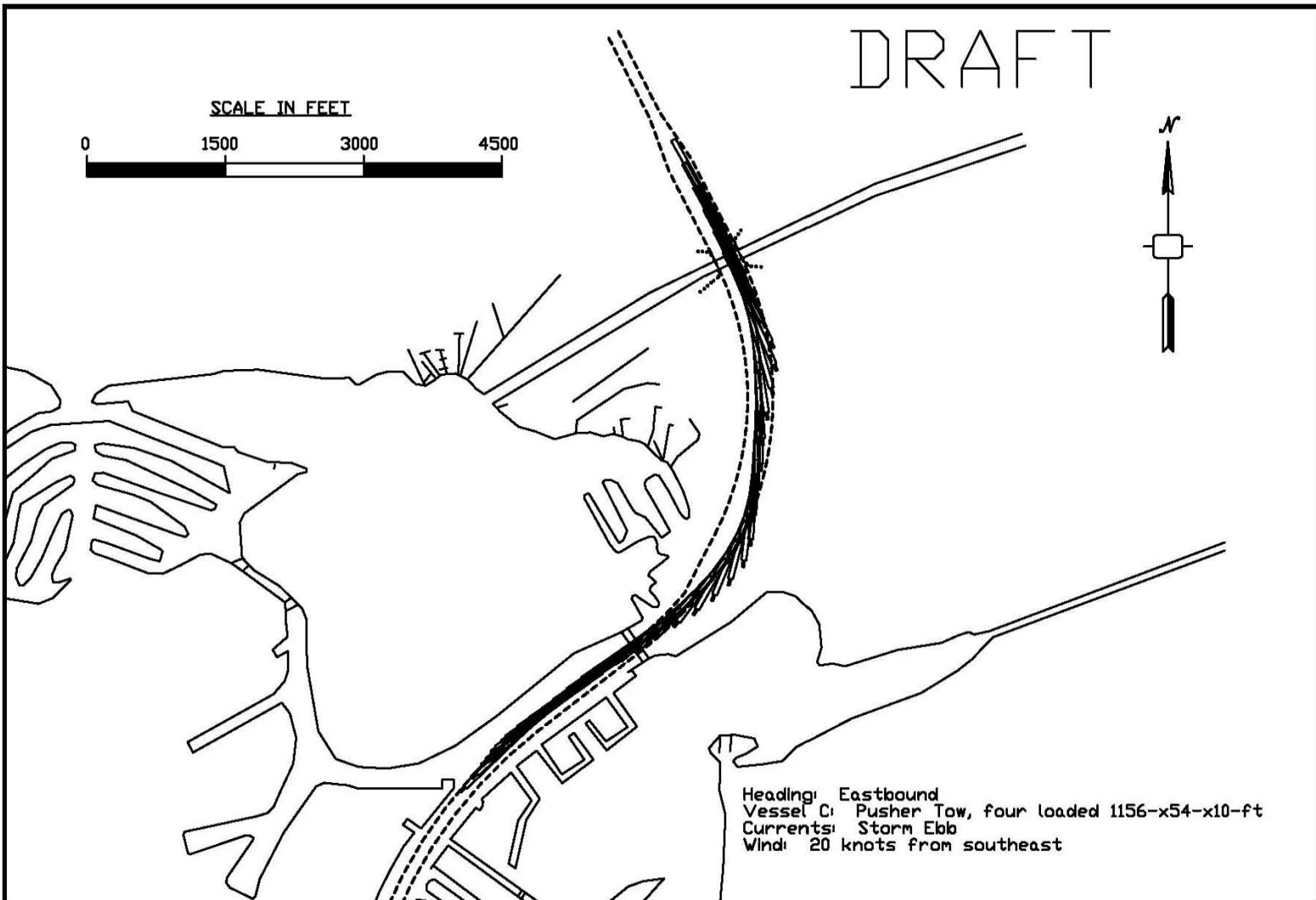


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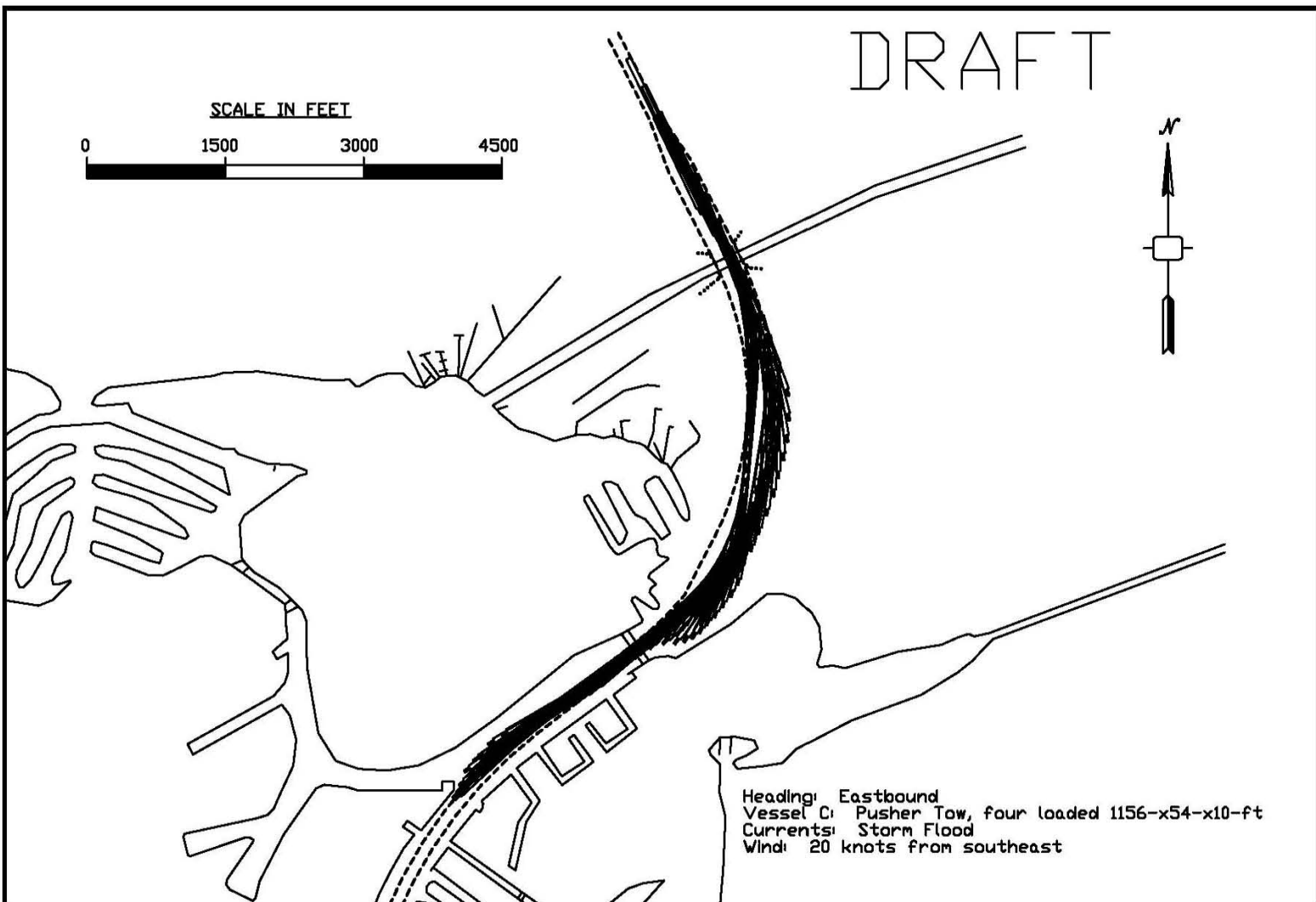


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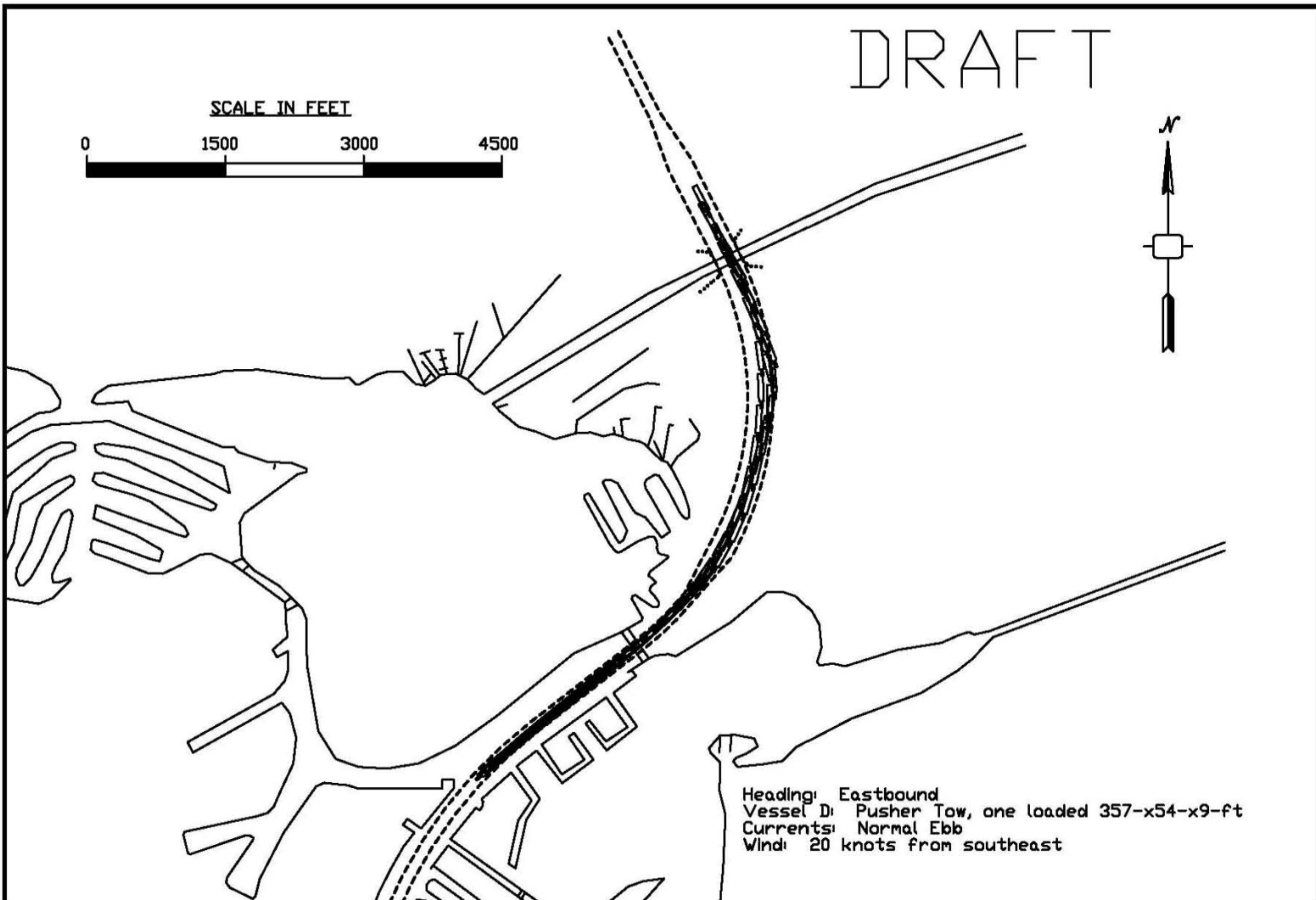


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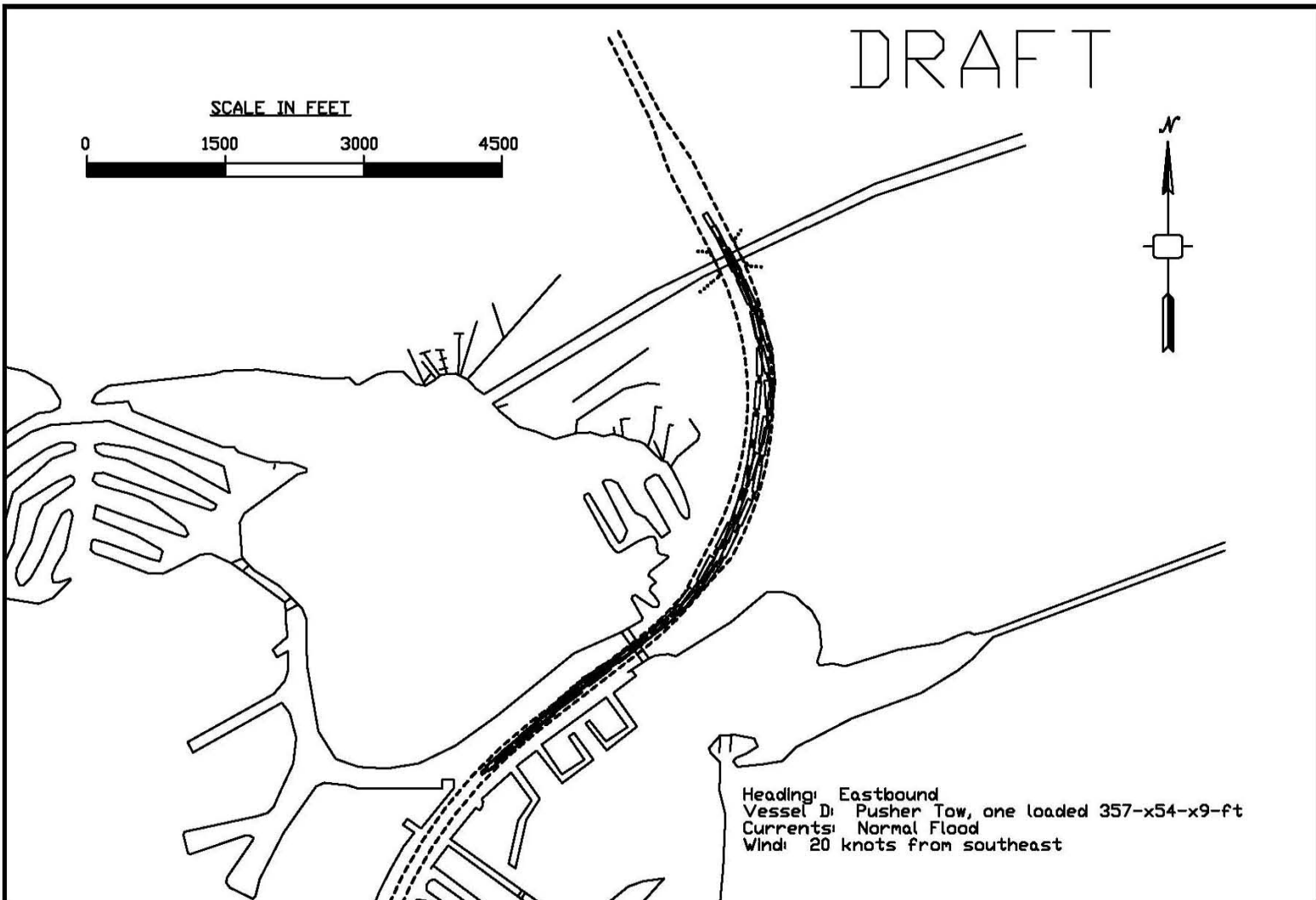


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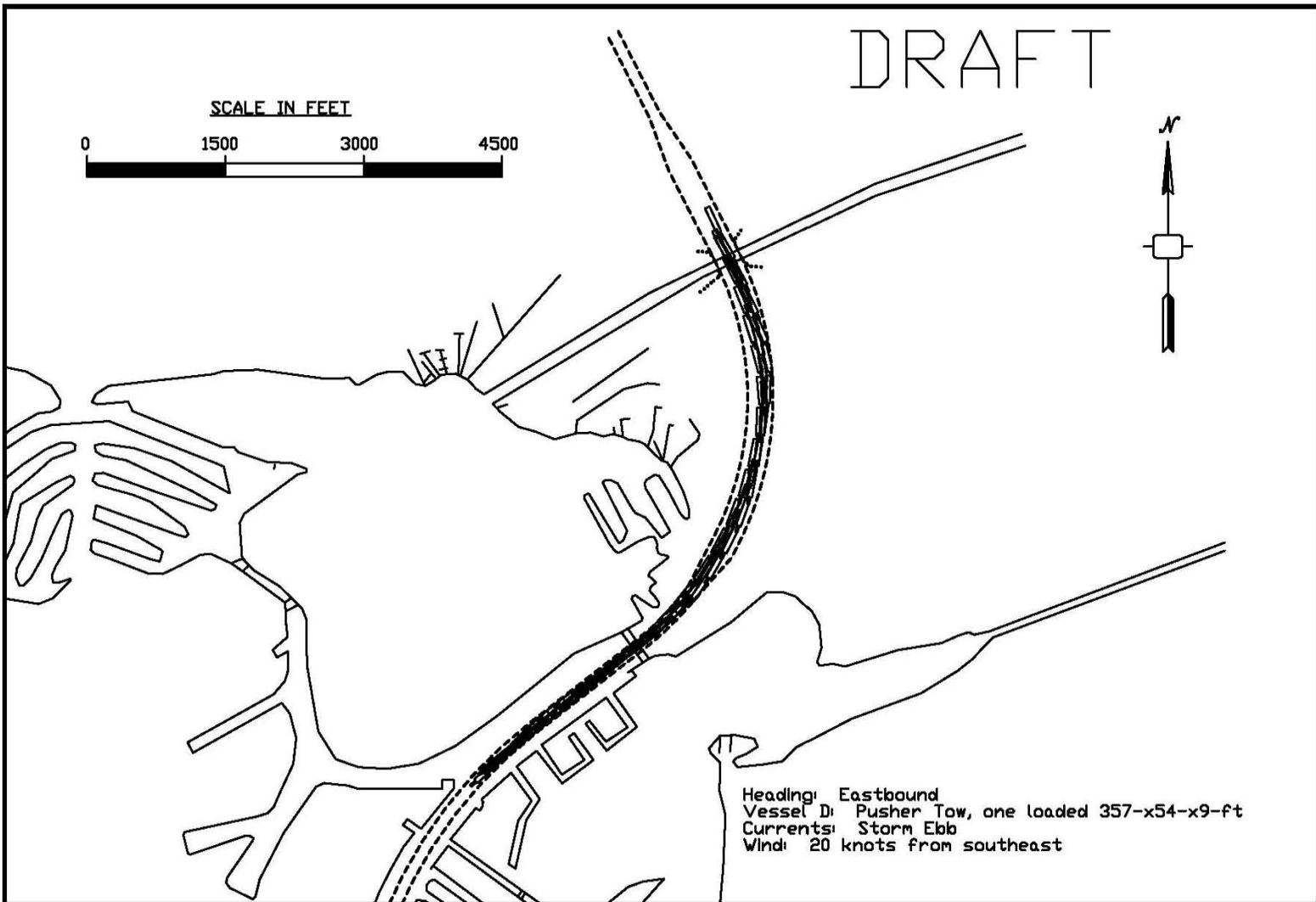


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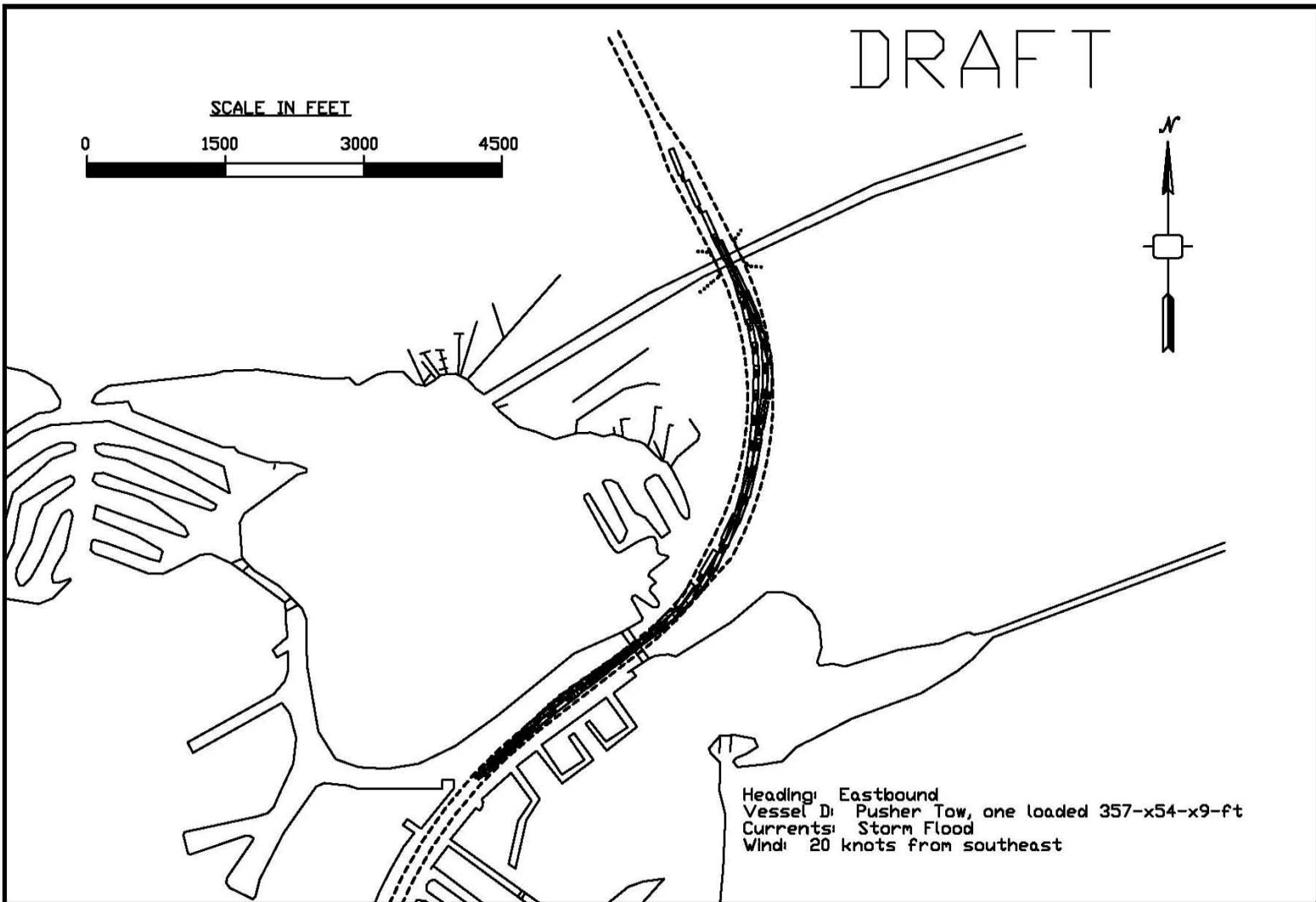


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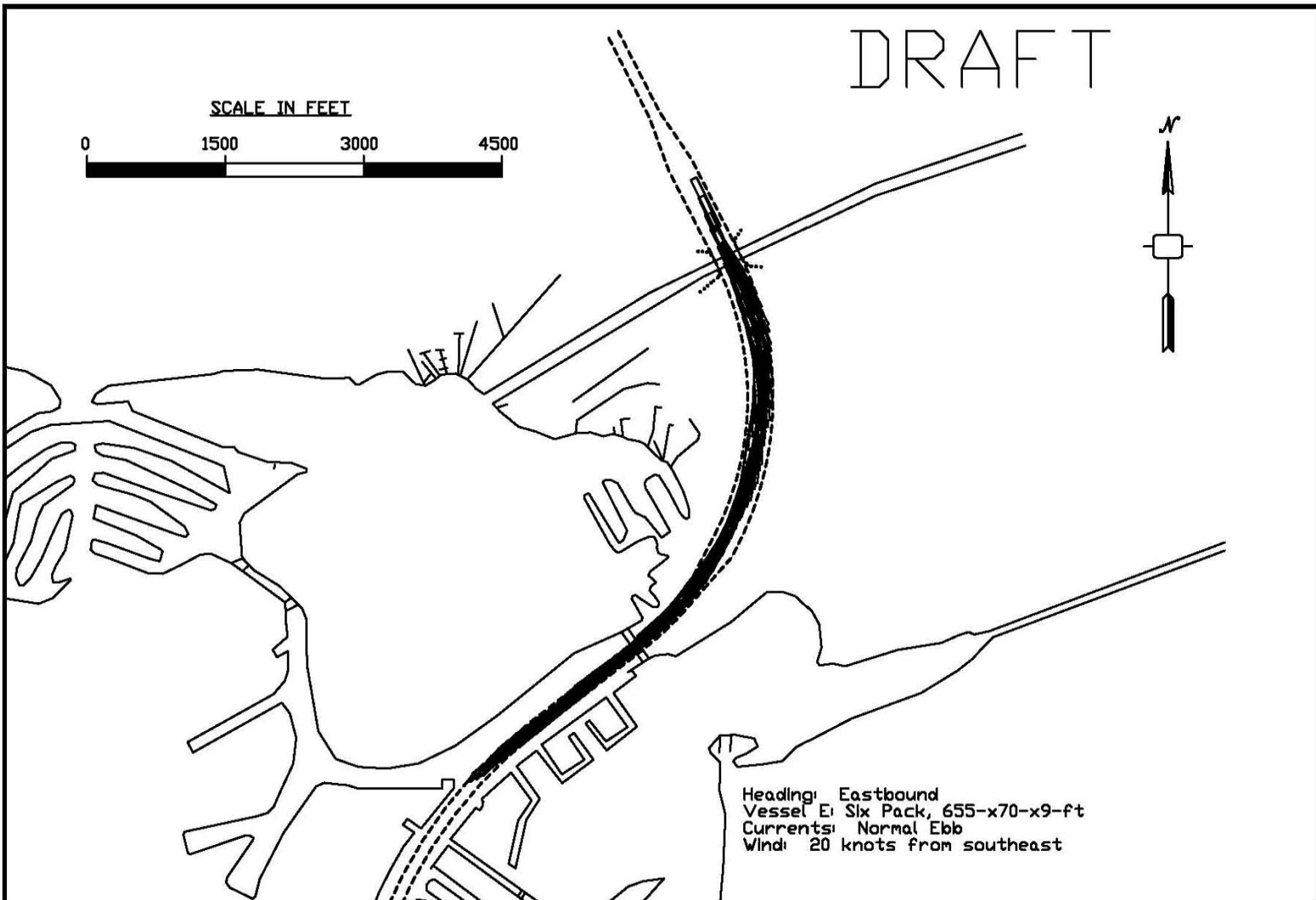


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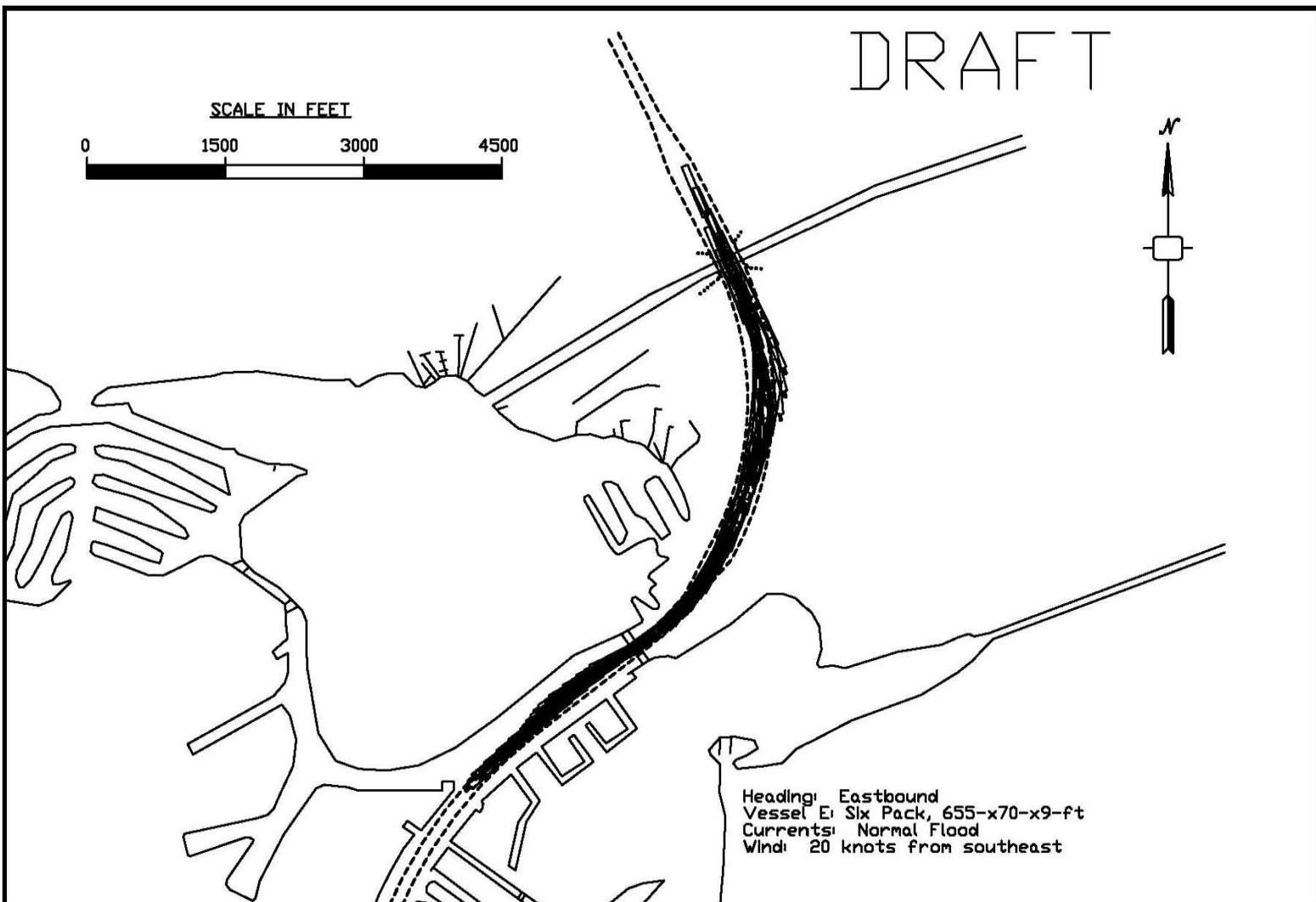


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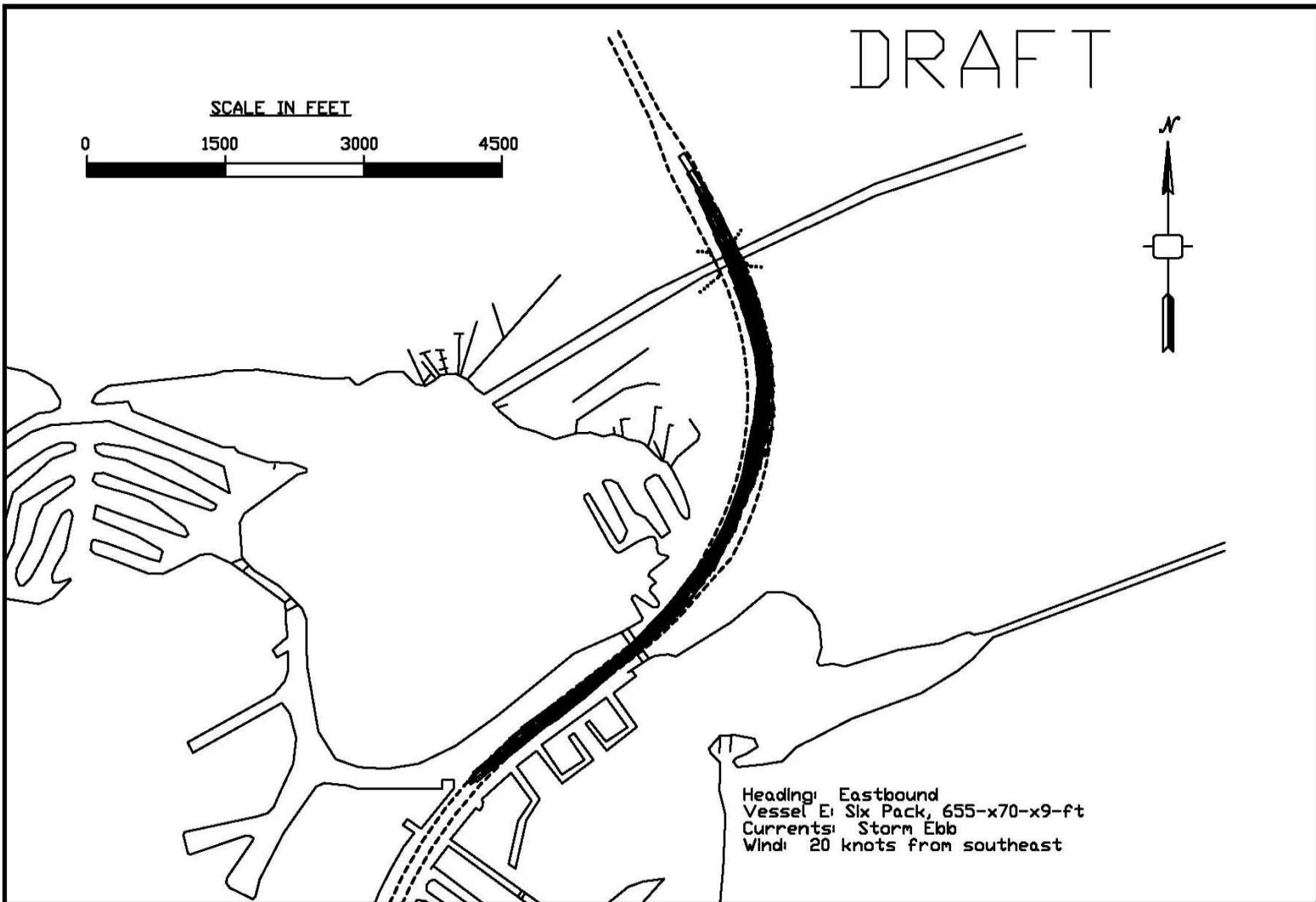


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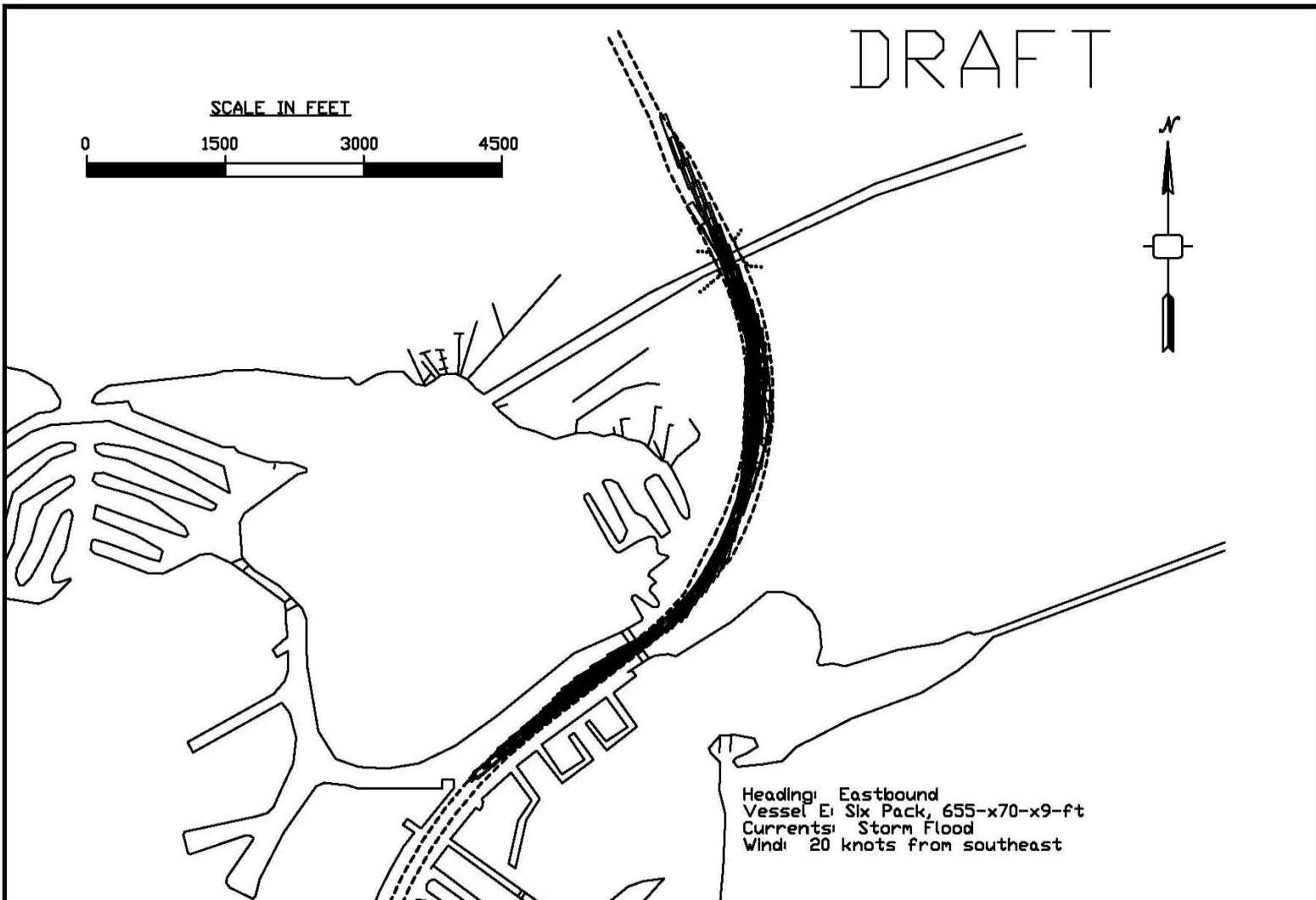


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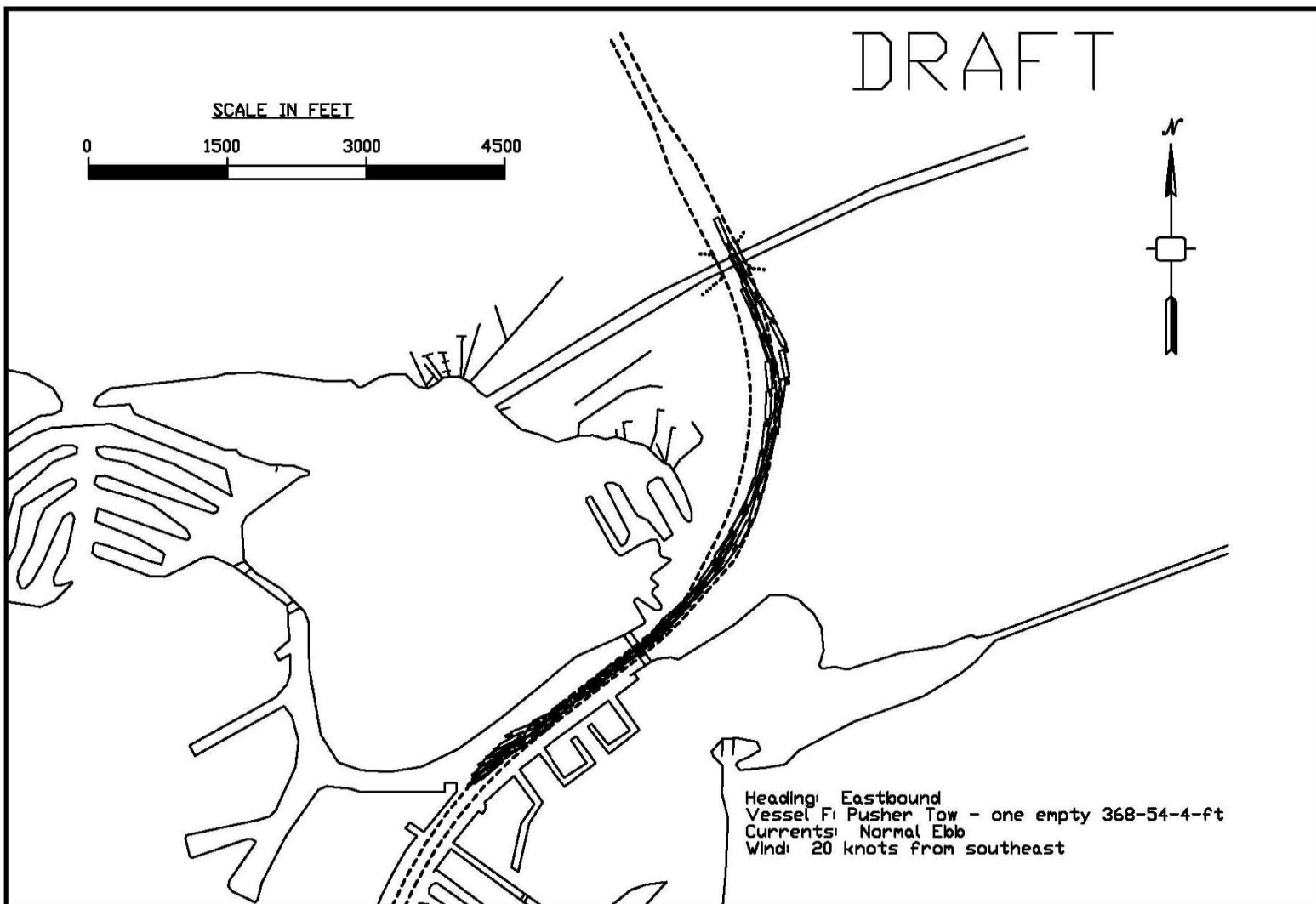


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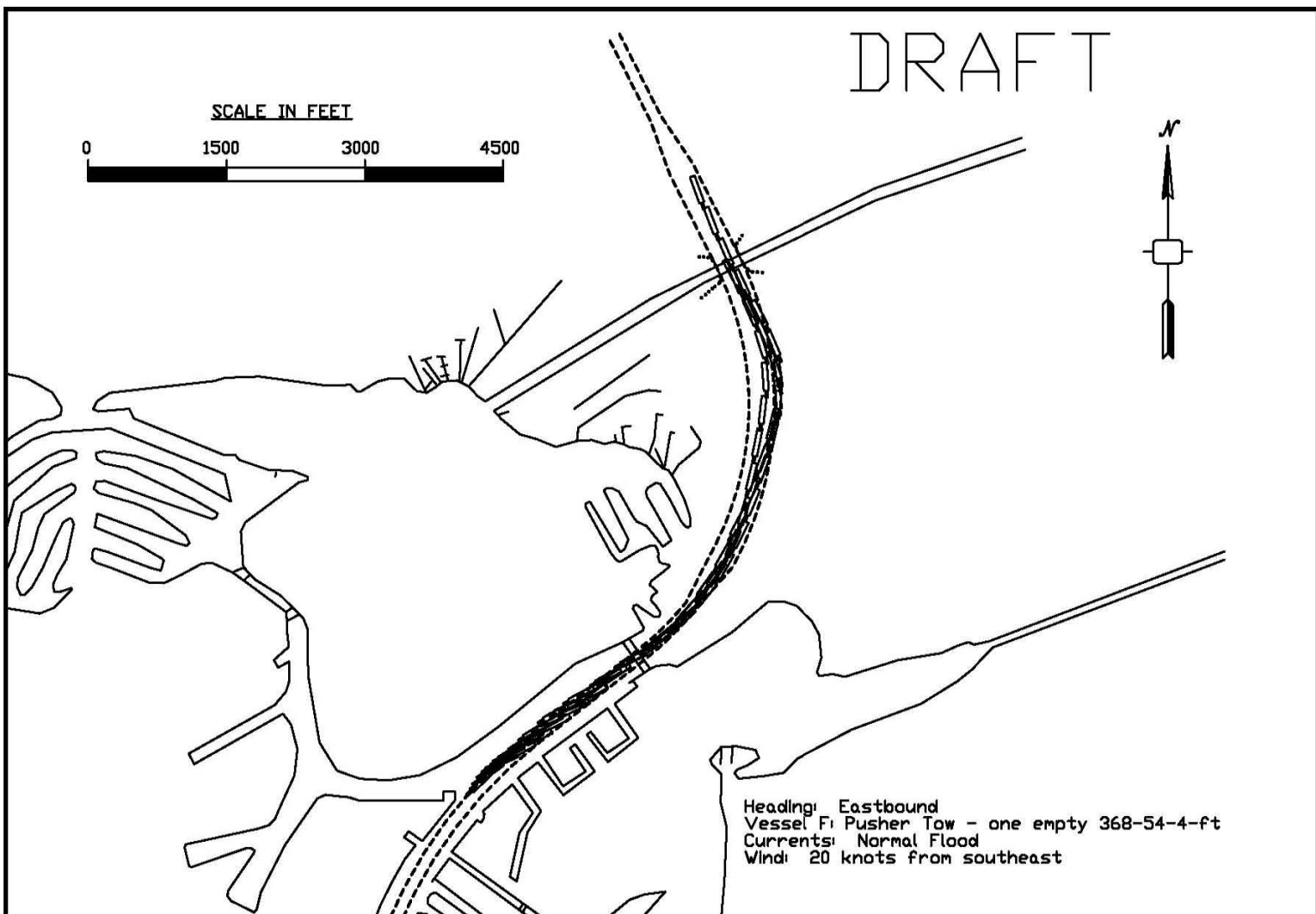


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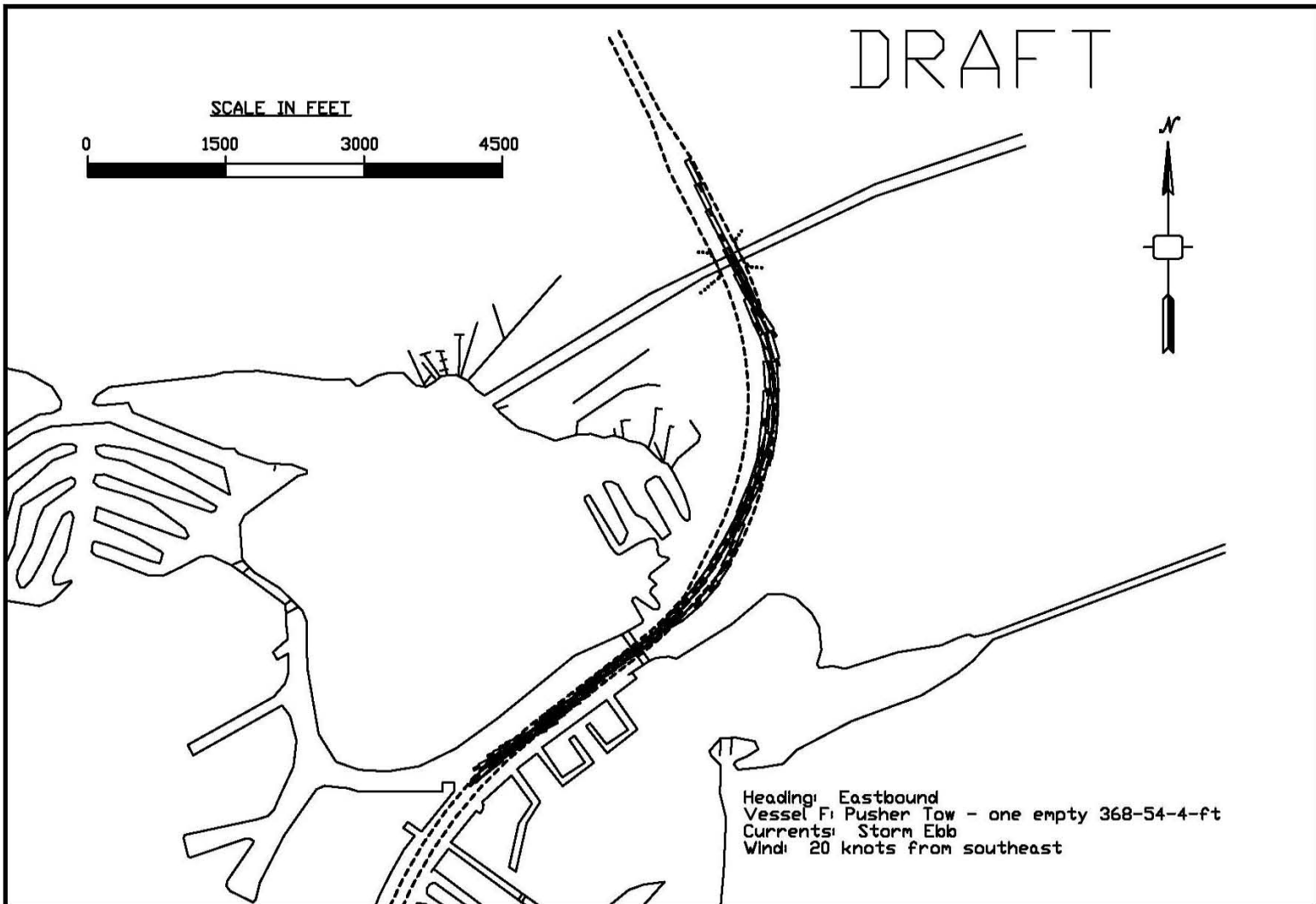


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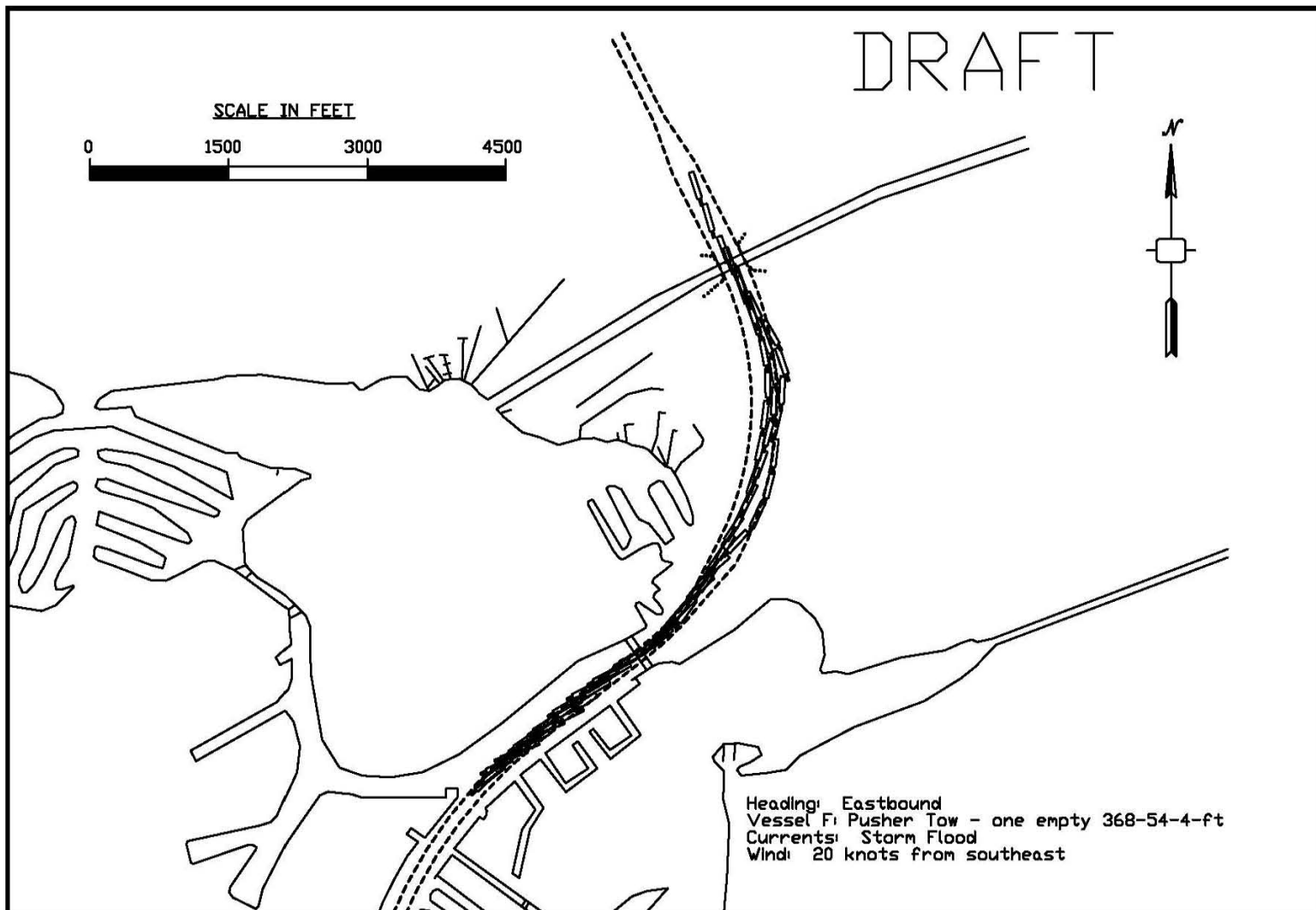


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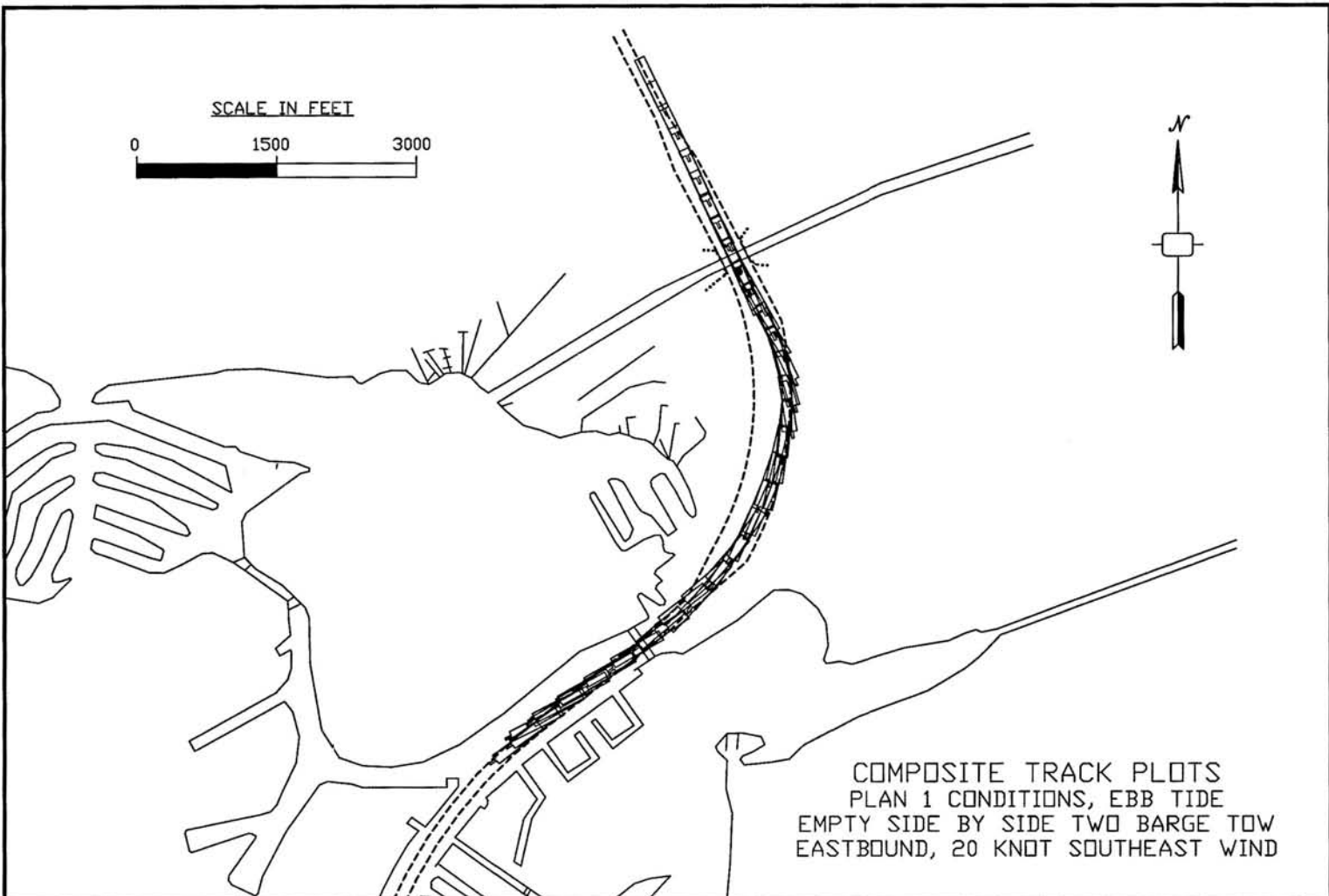


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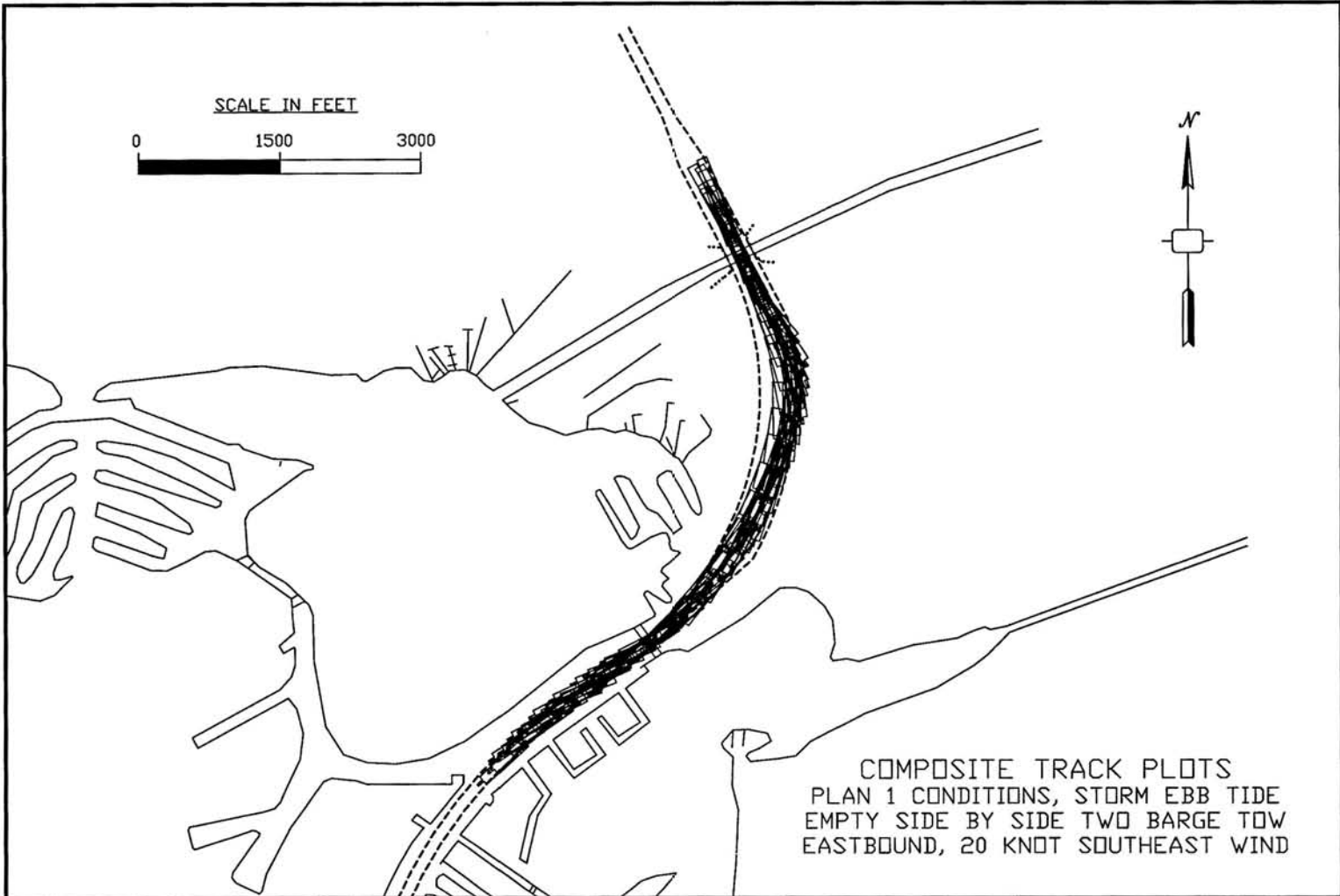


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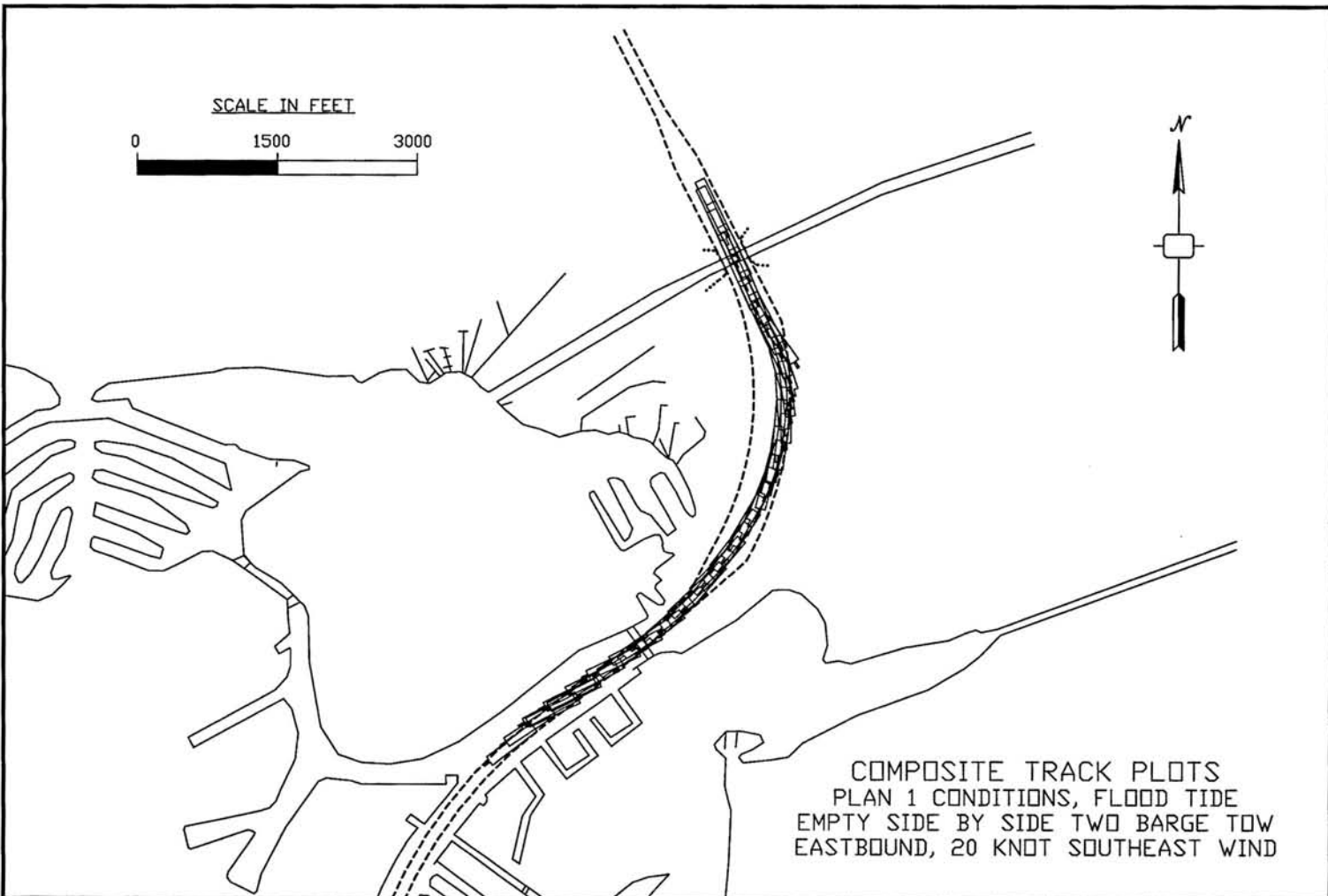


Plate 23

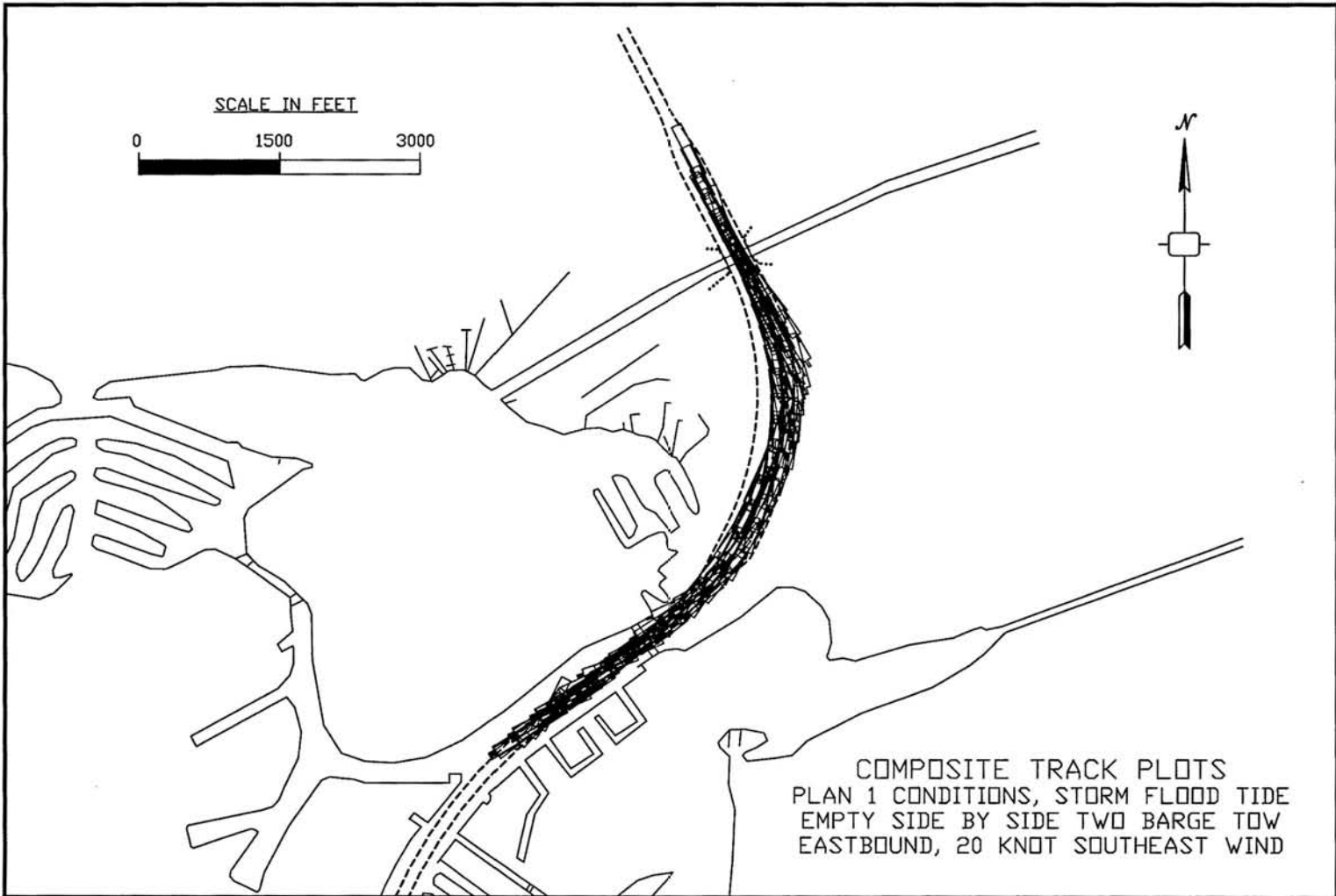
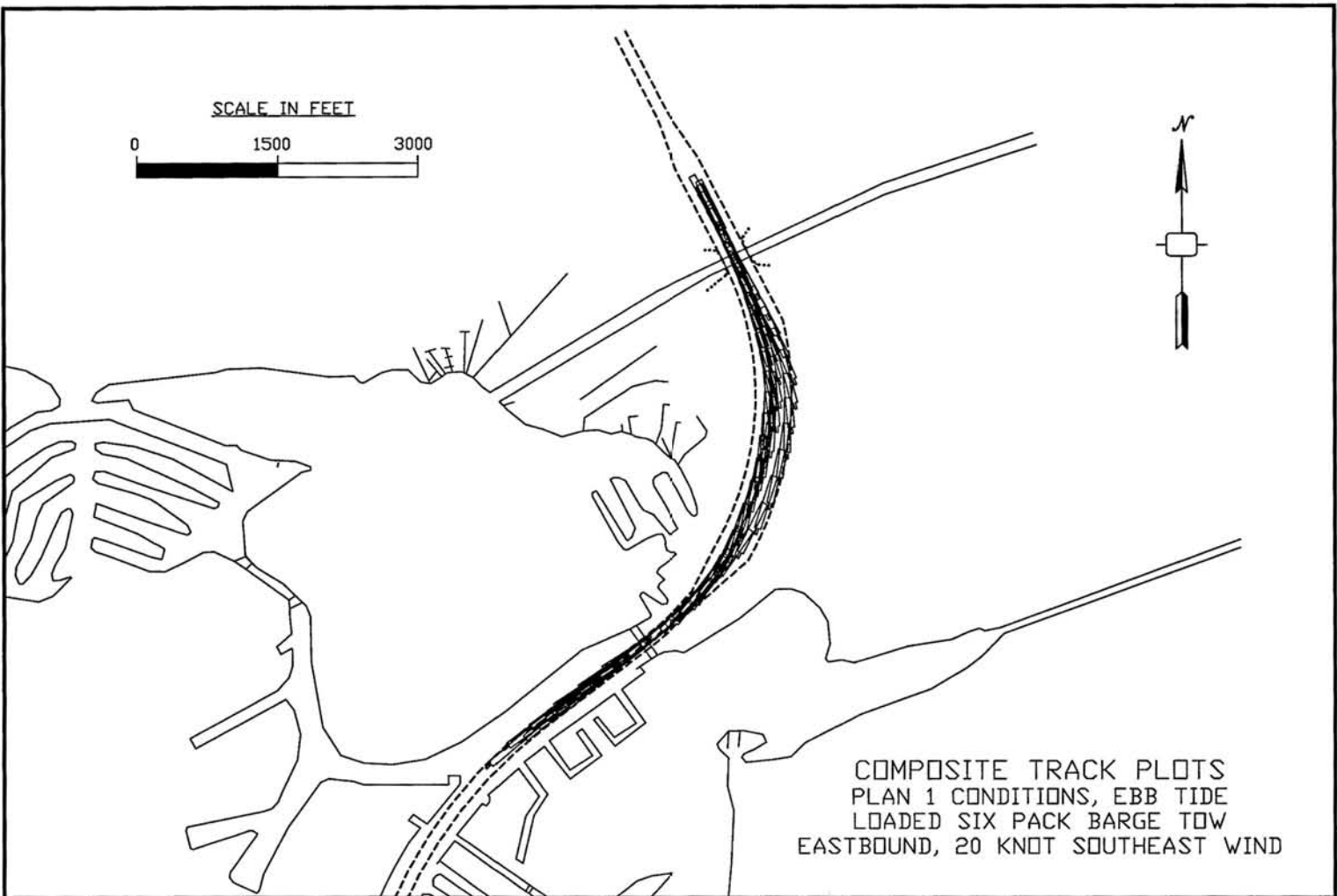


Plate 24



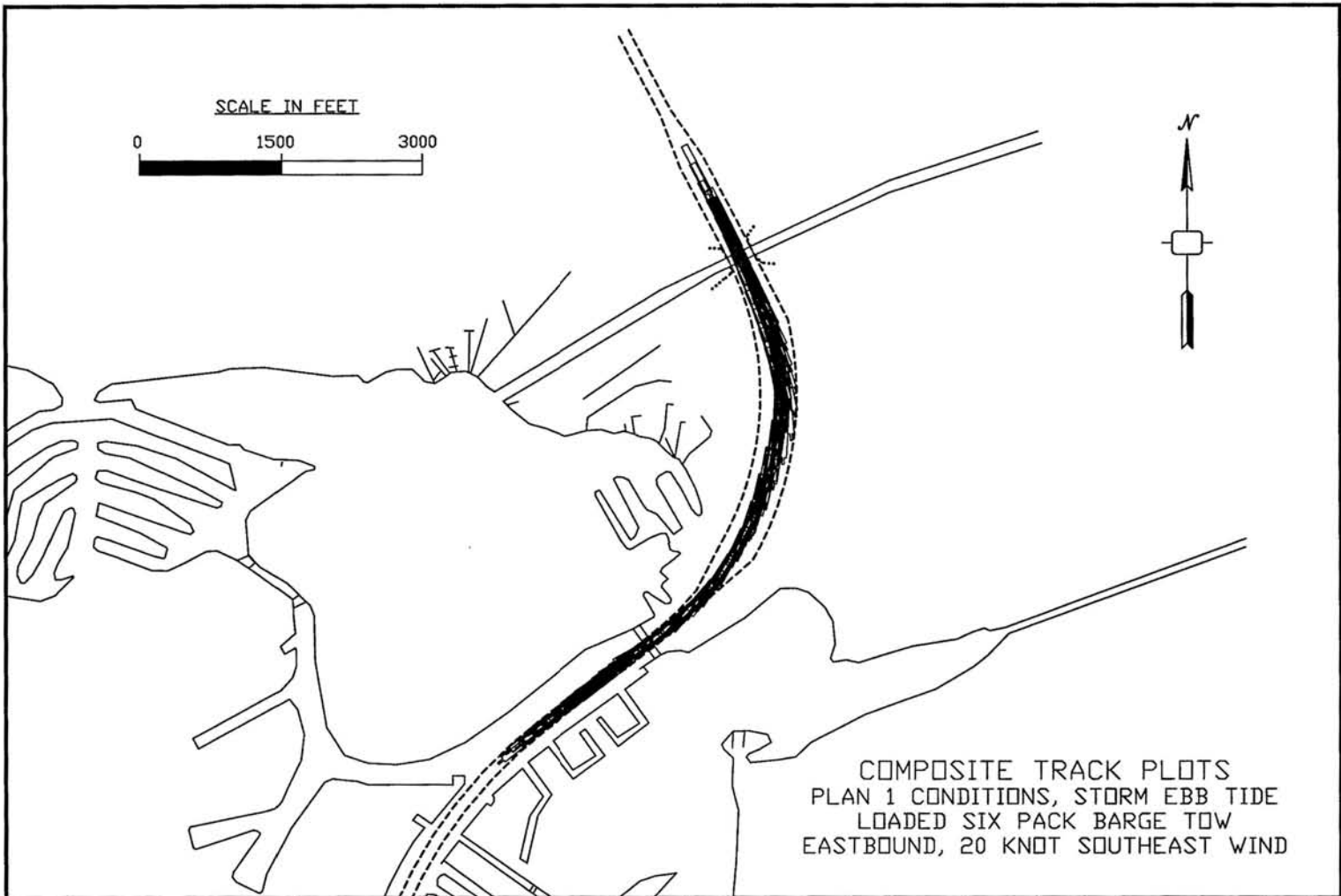
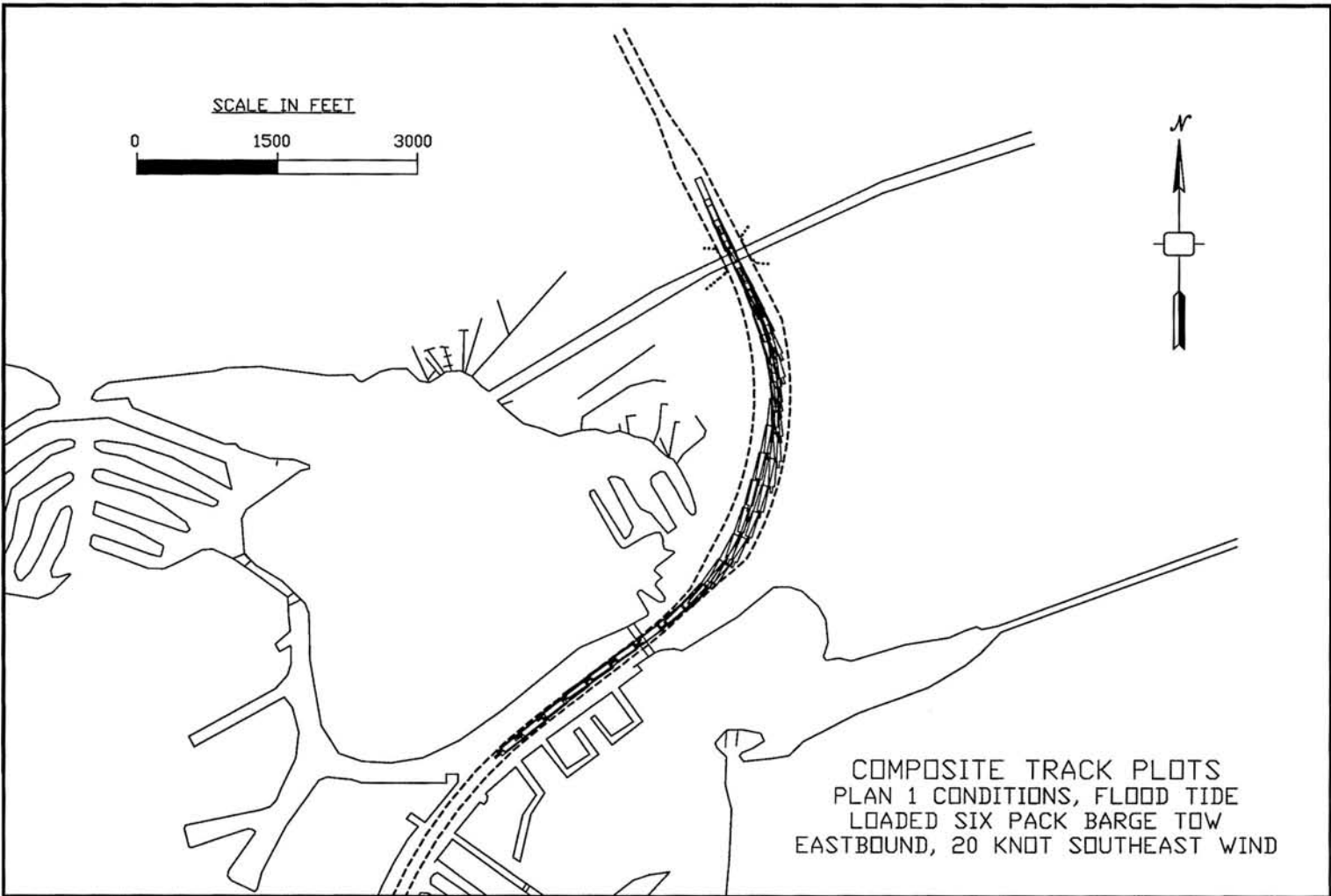
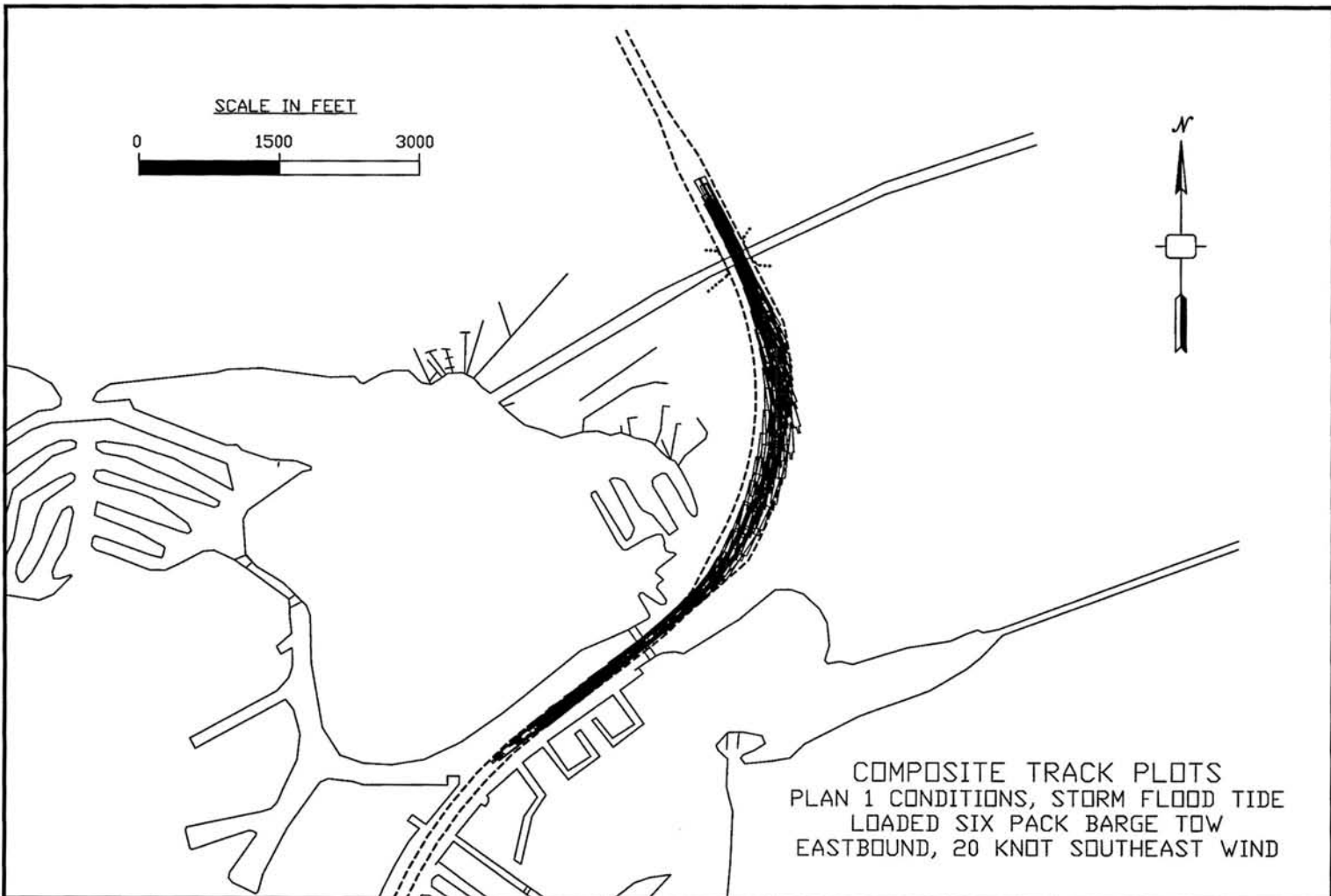


Plate 26





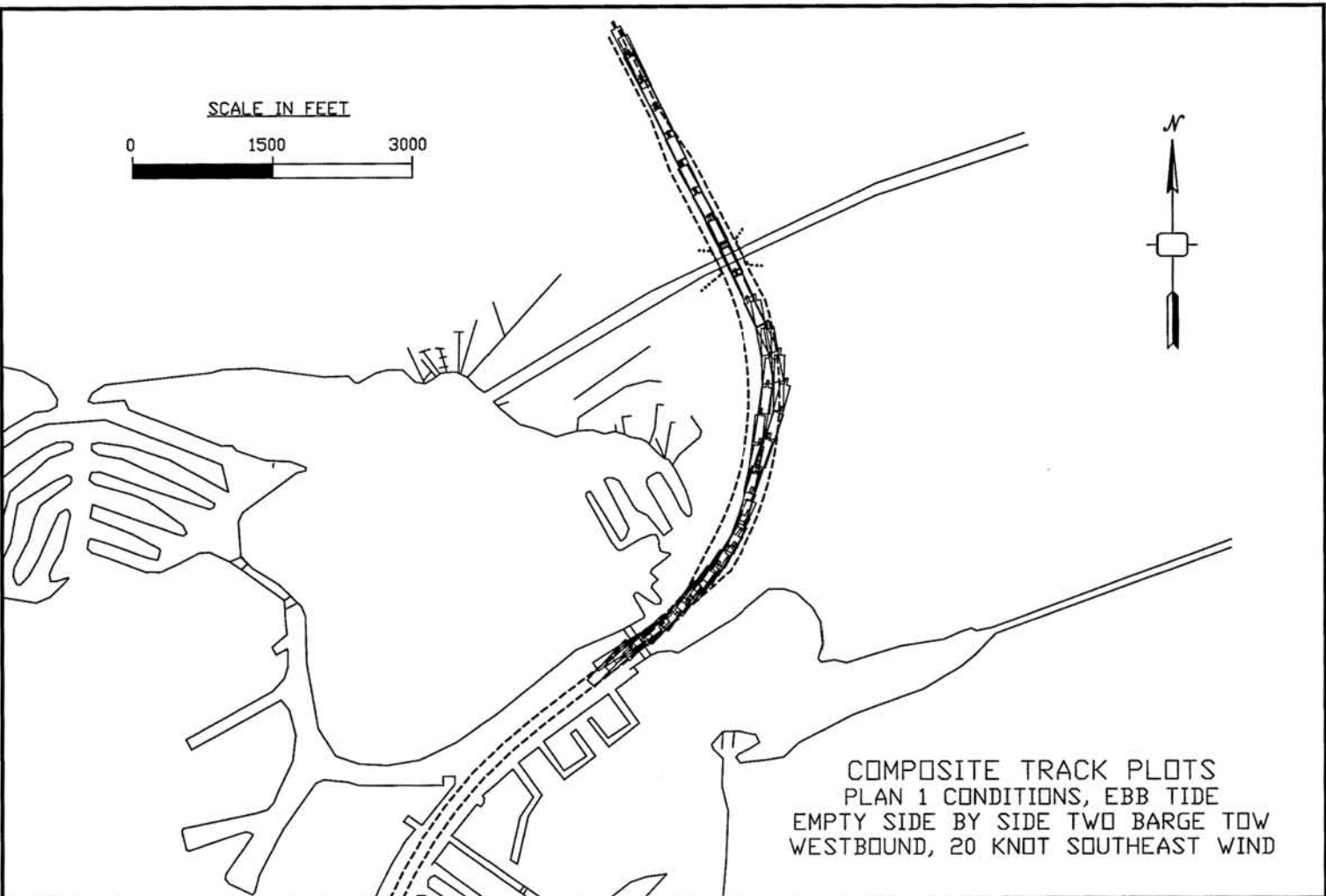


Plate 29

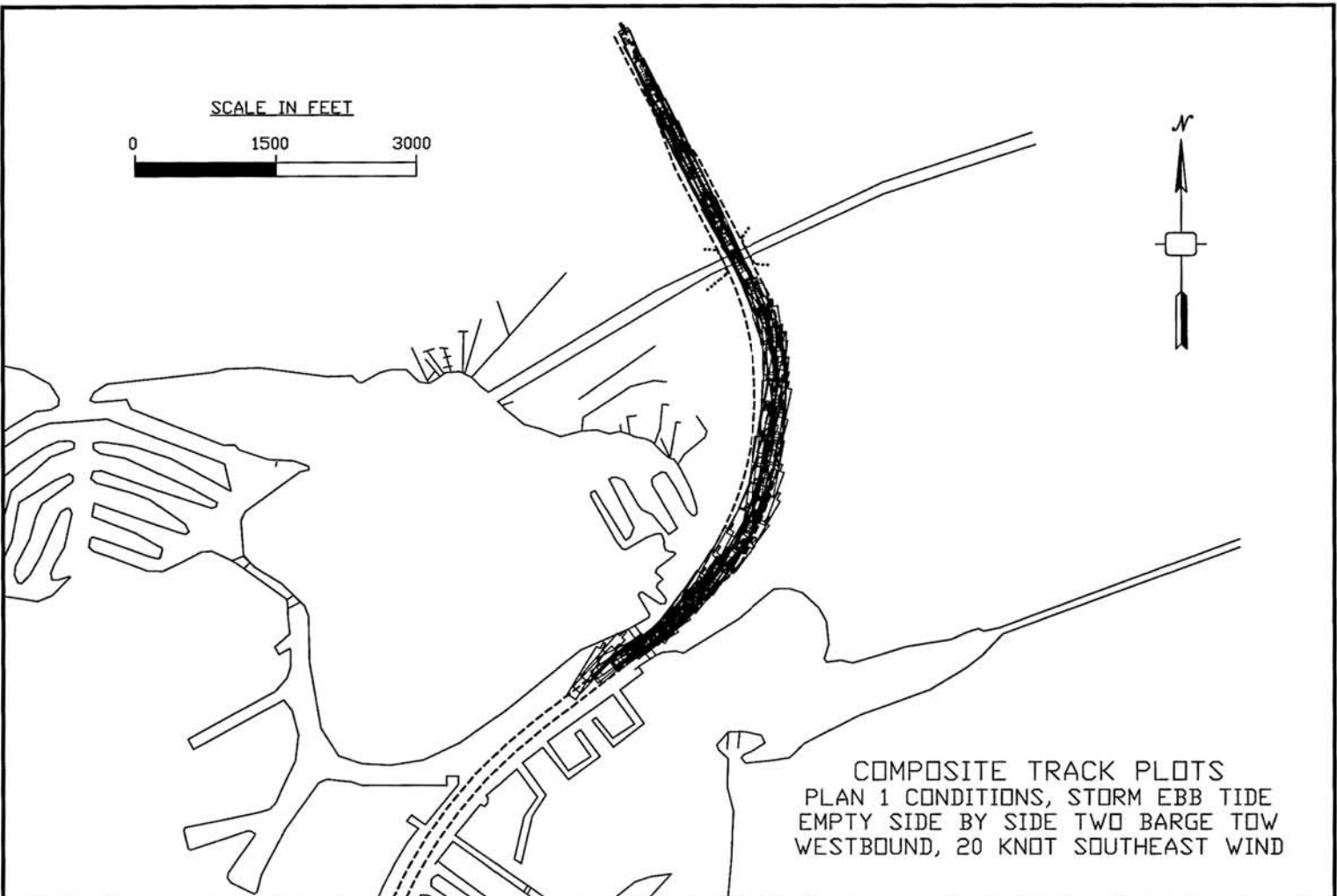


Plate 30

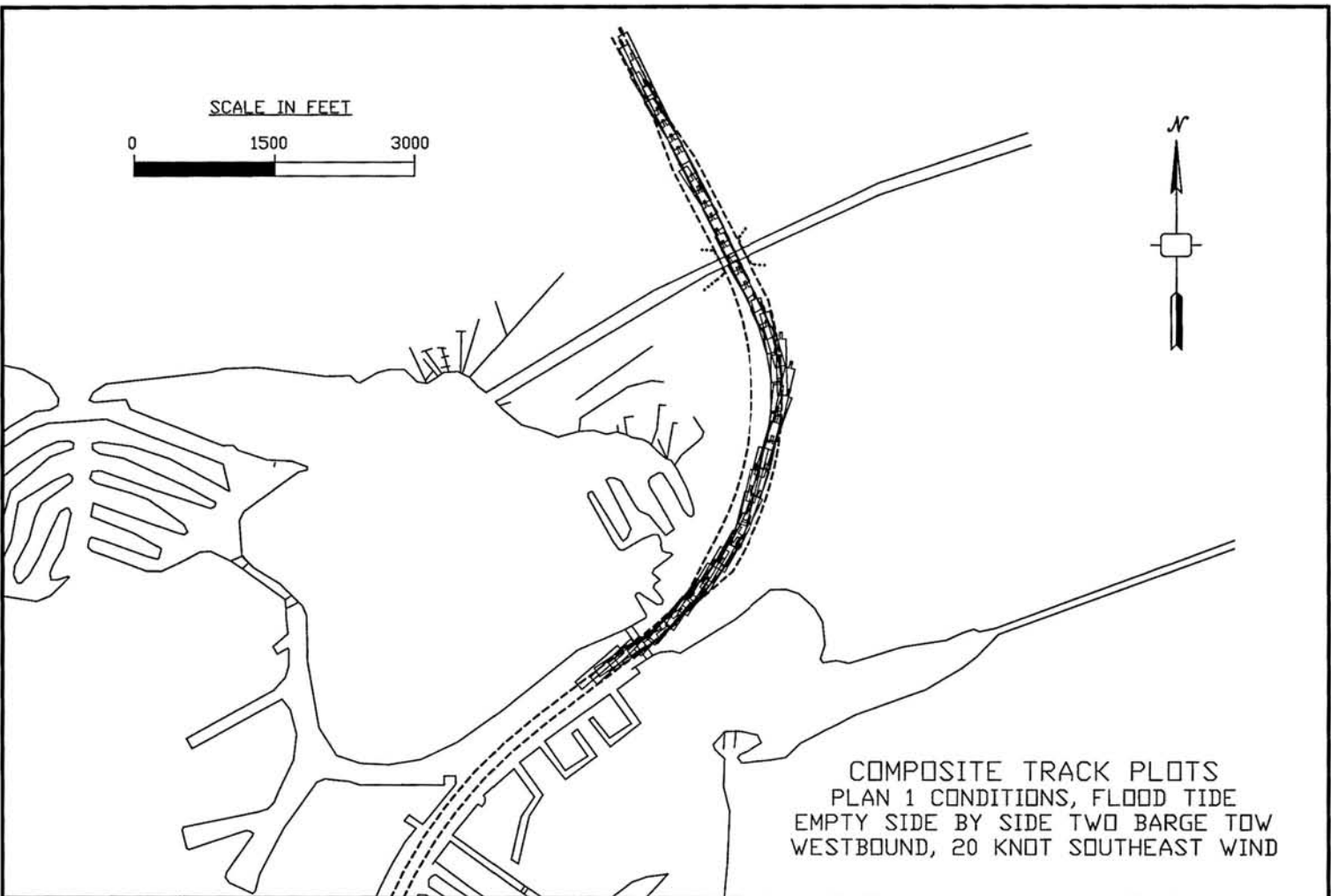


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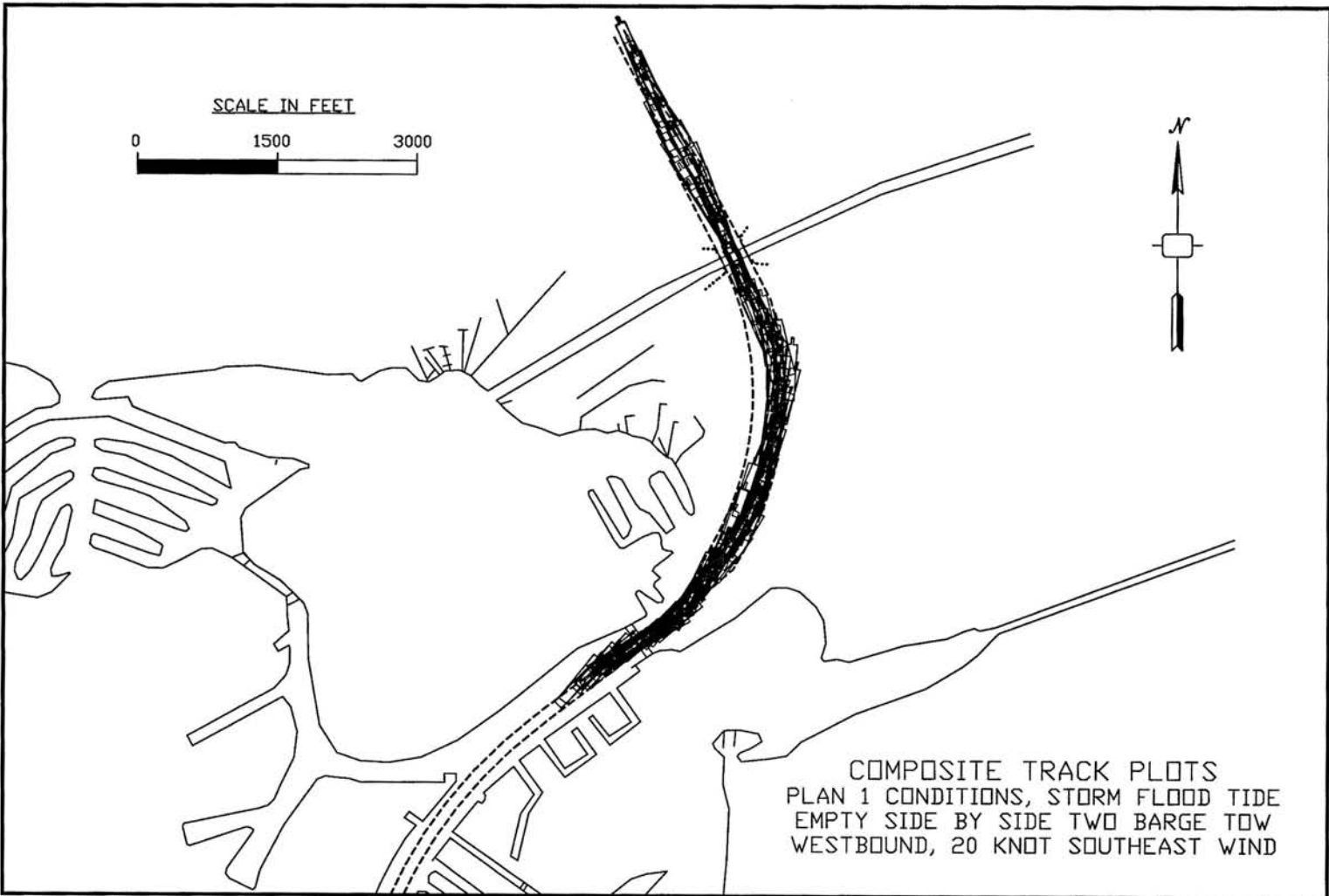


Plate 32

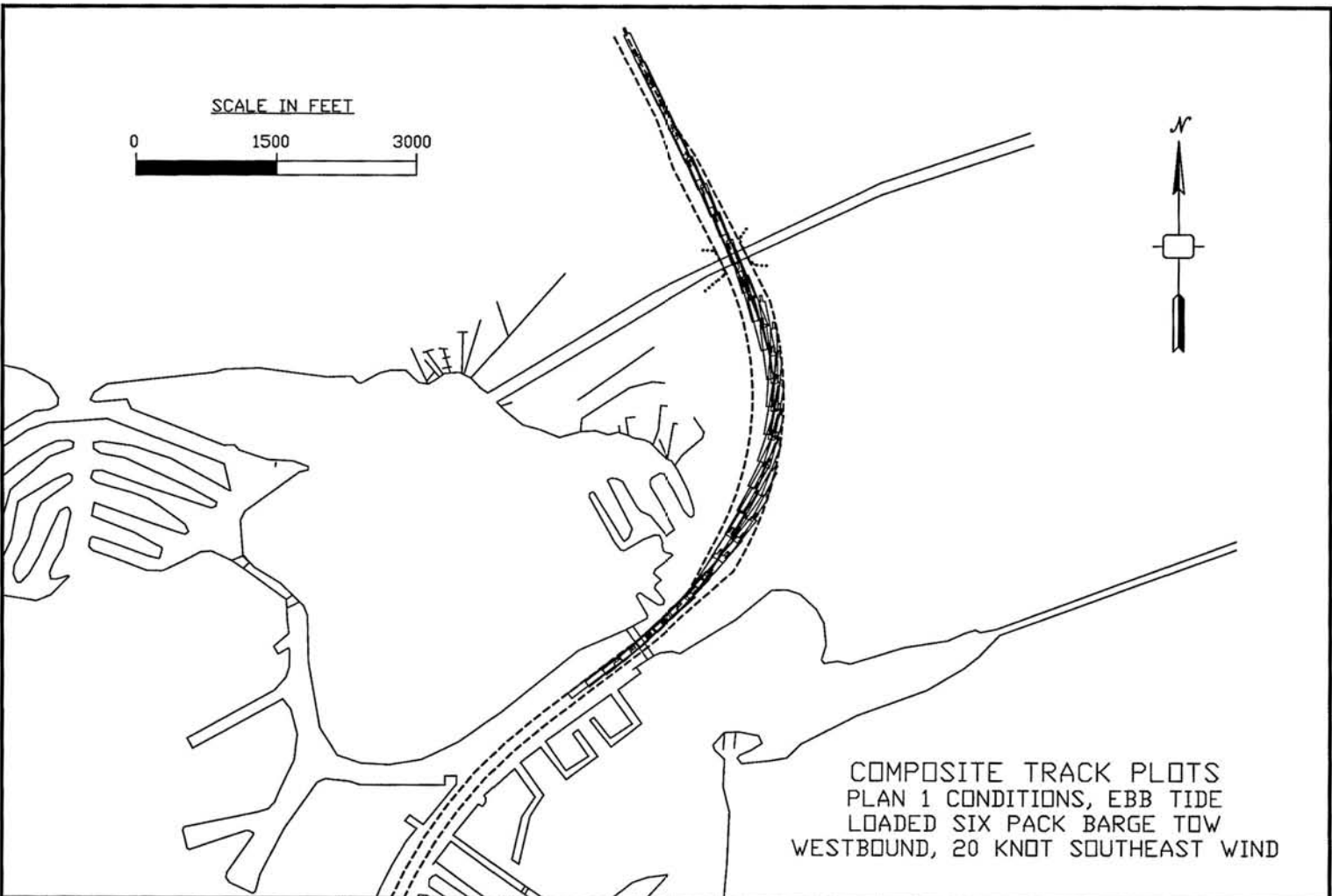


Plate 33

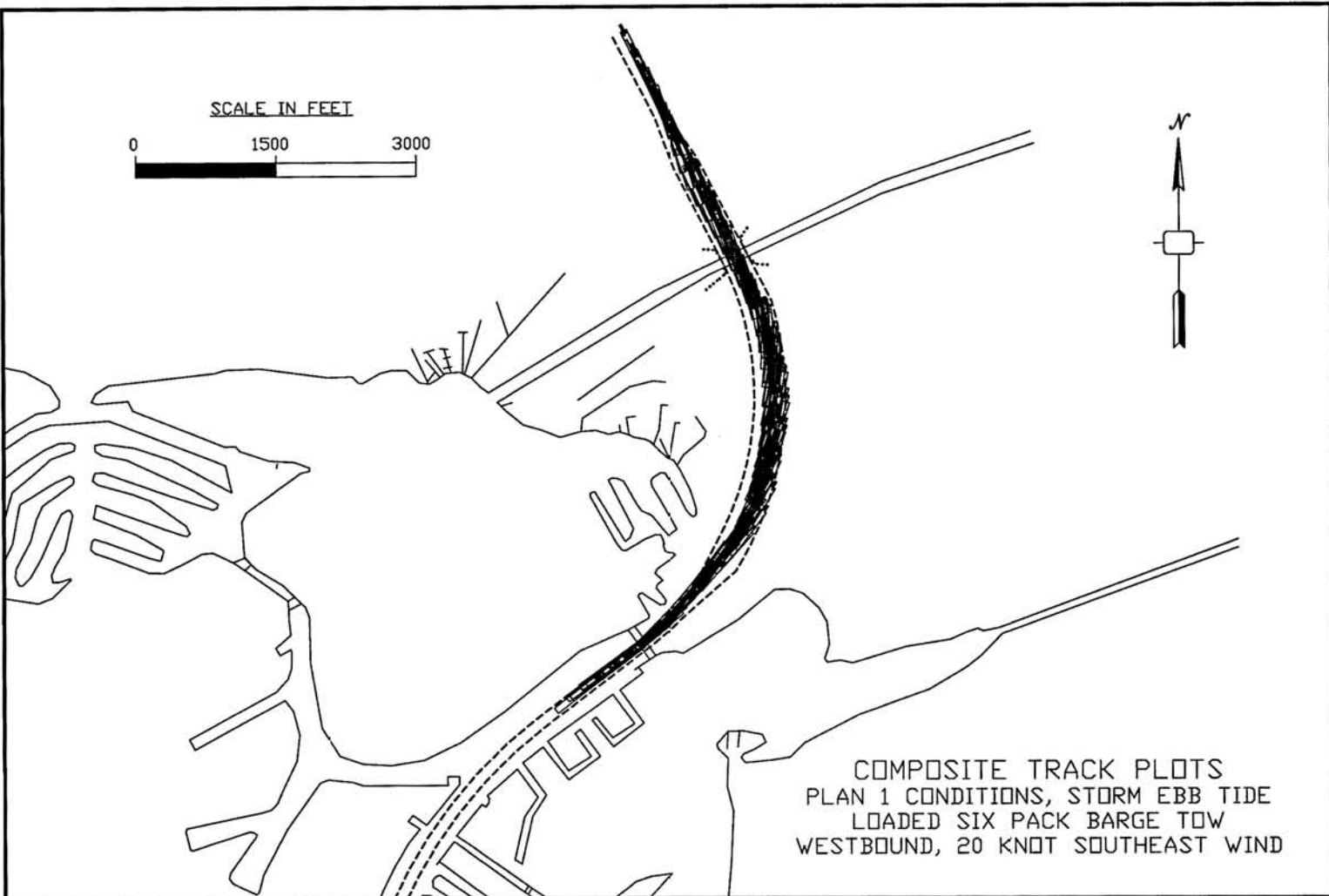


Plate 34

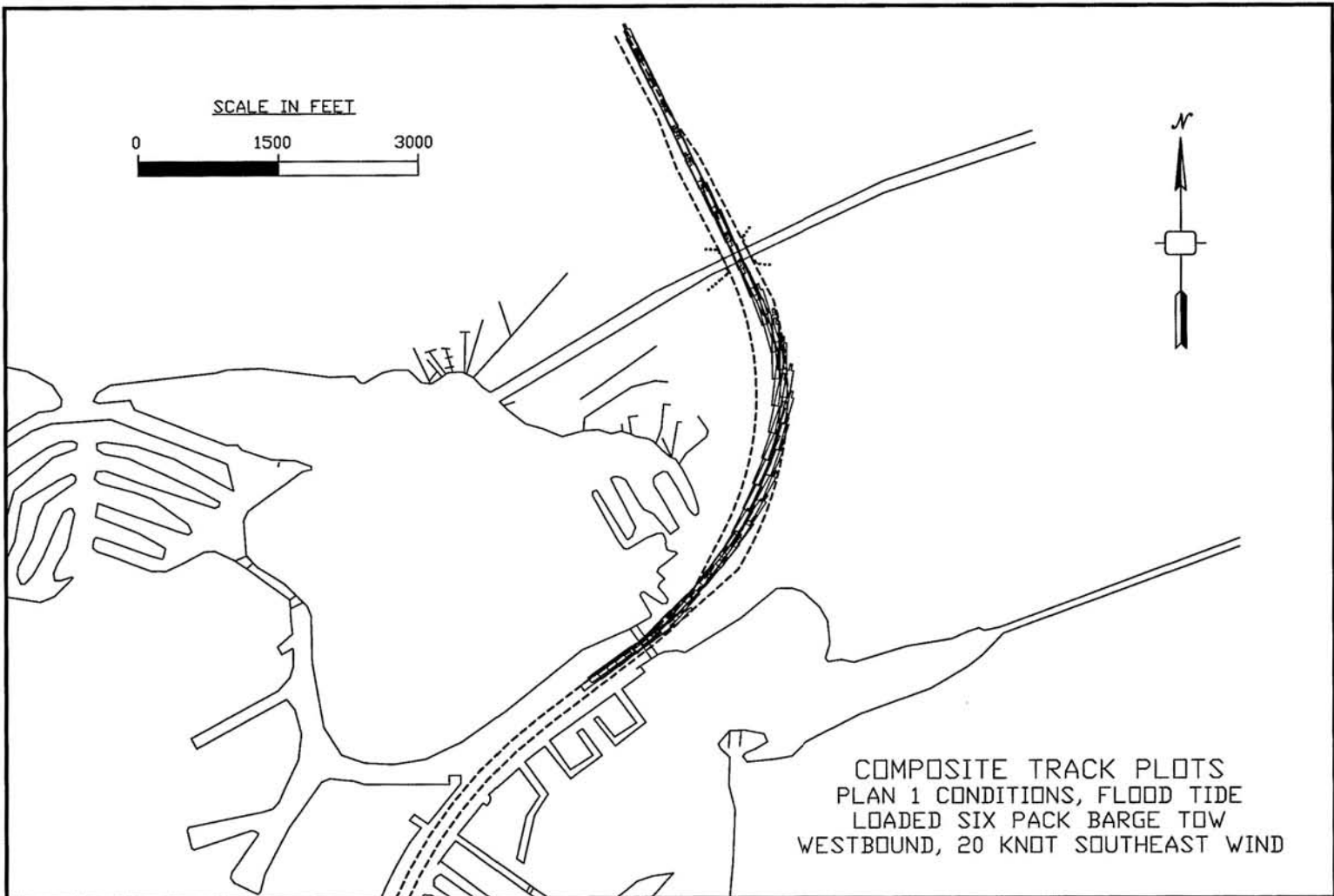
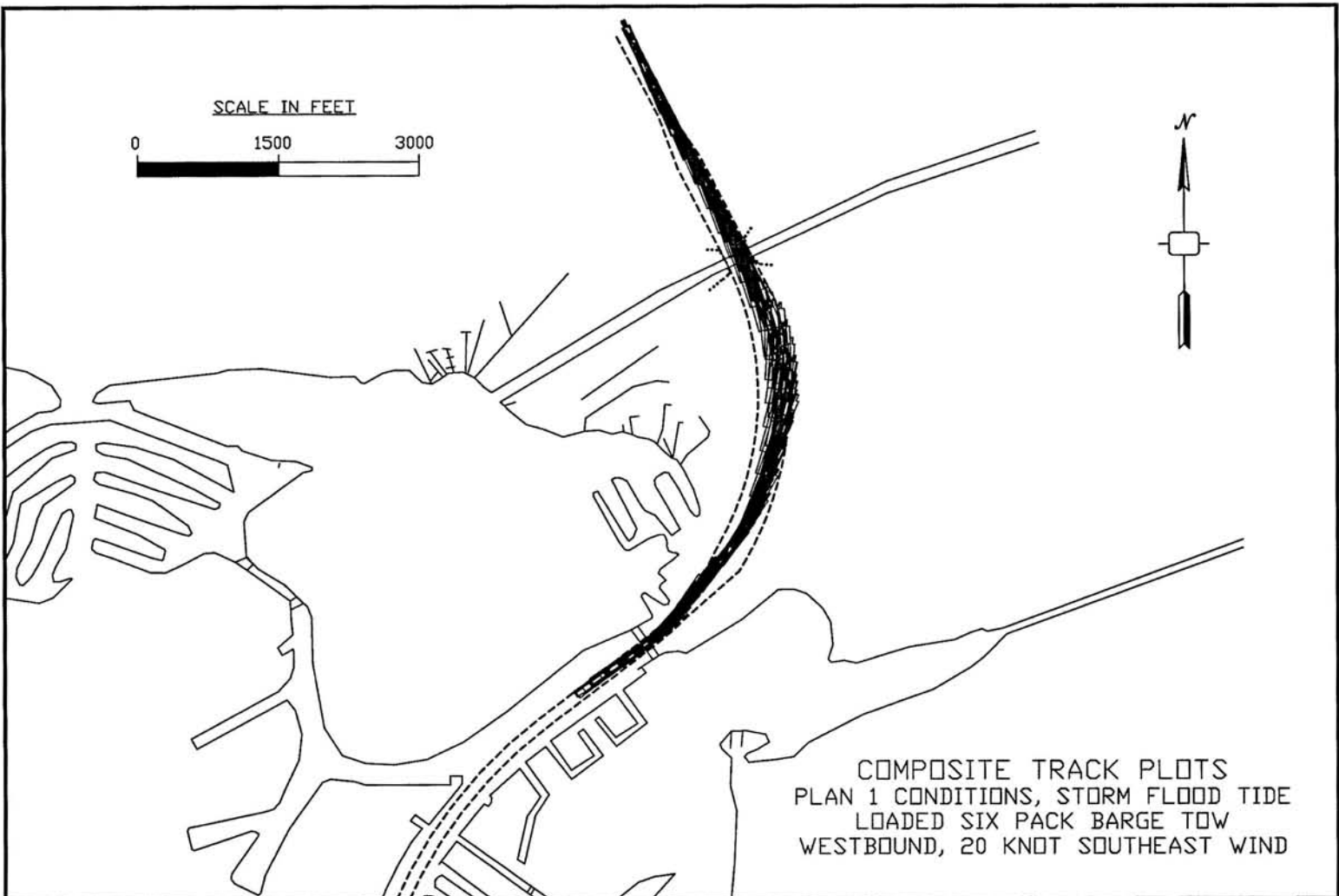
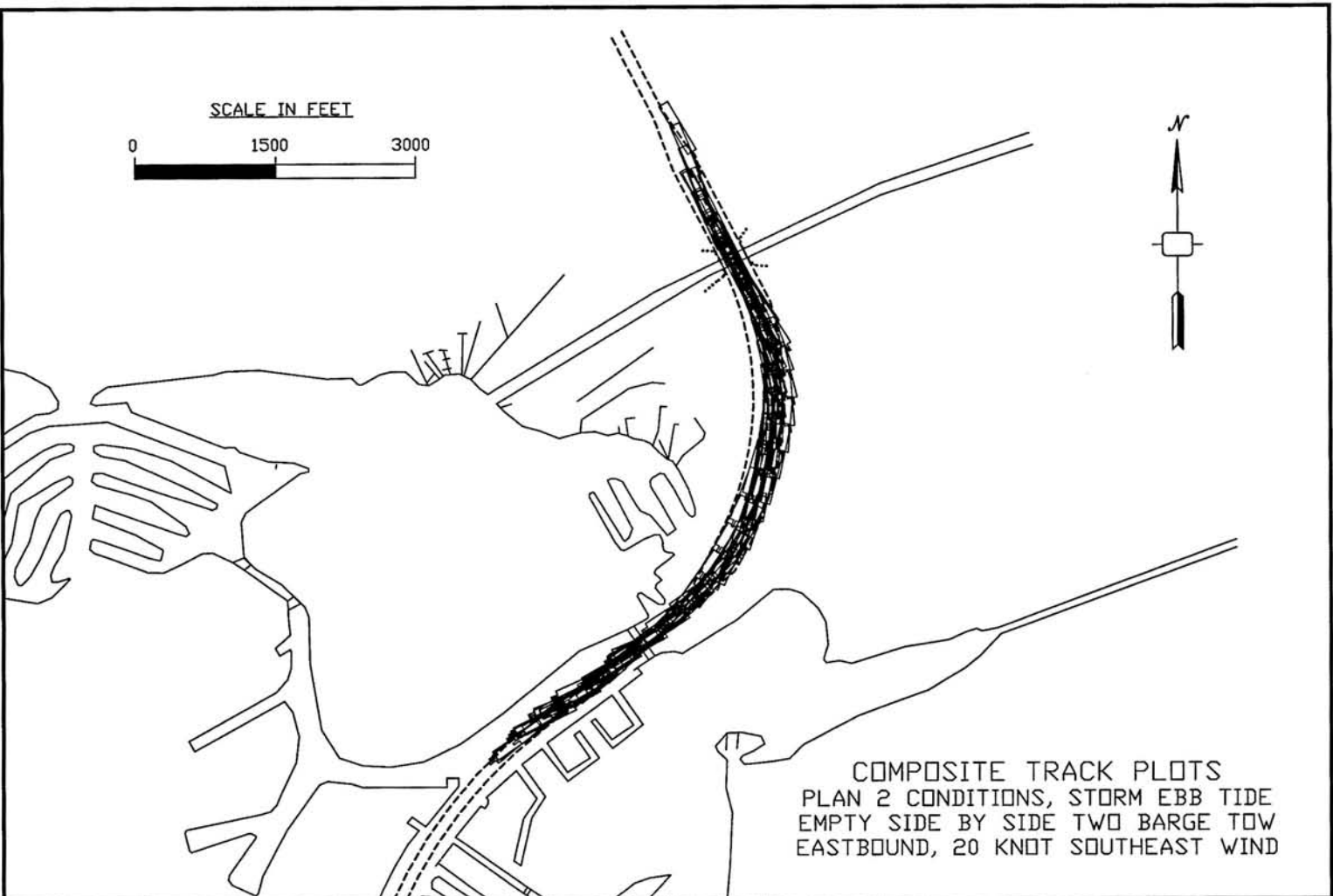


Plate 35





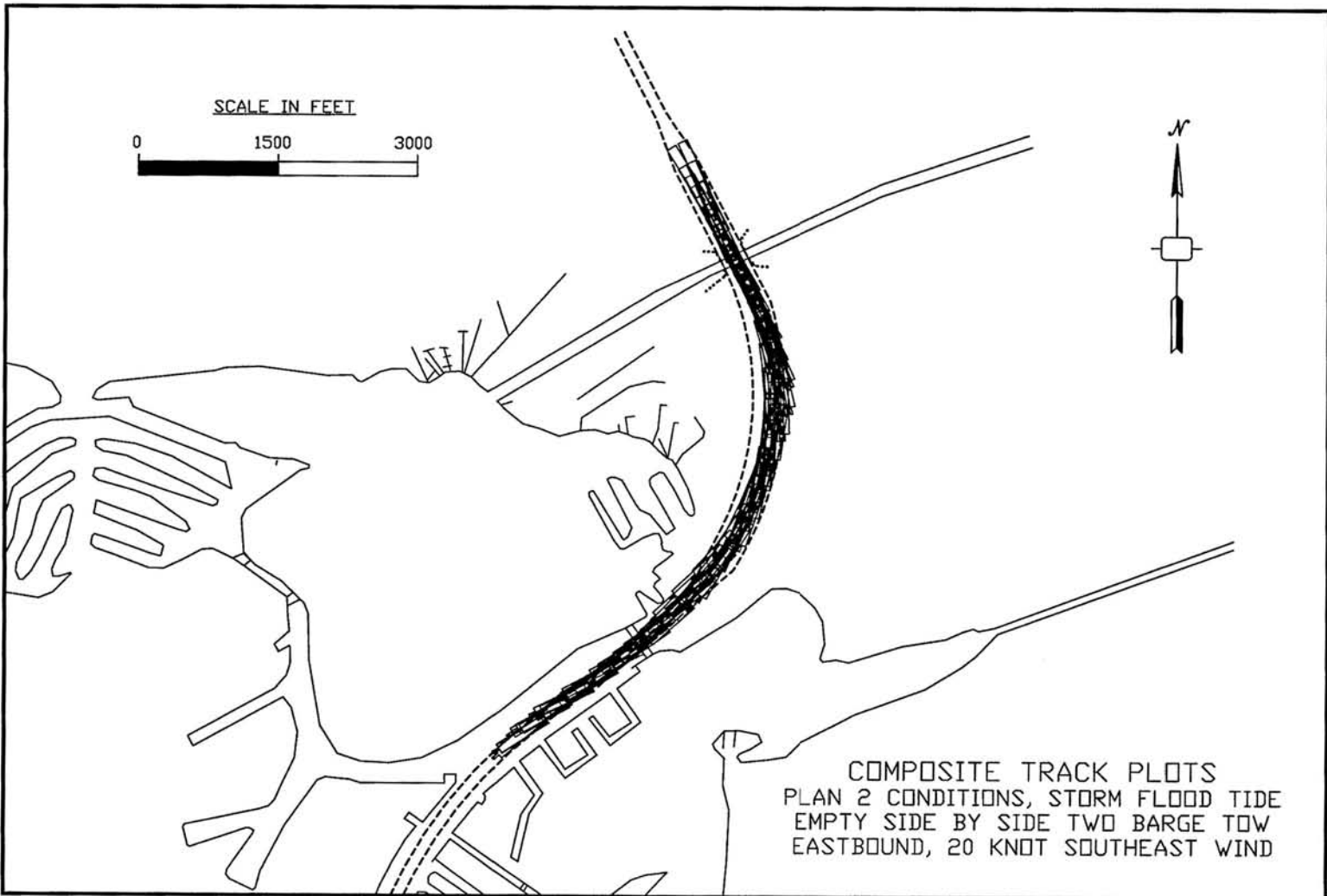


Plate 38

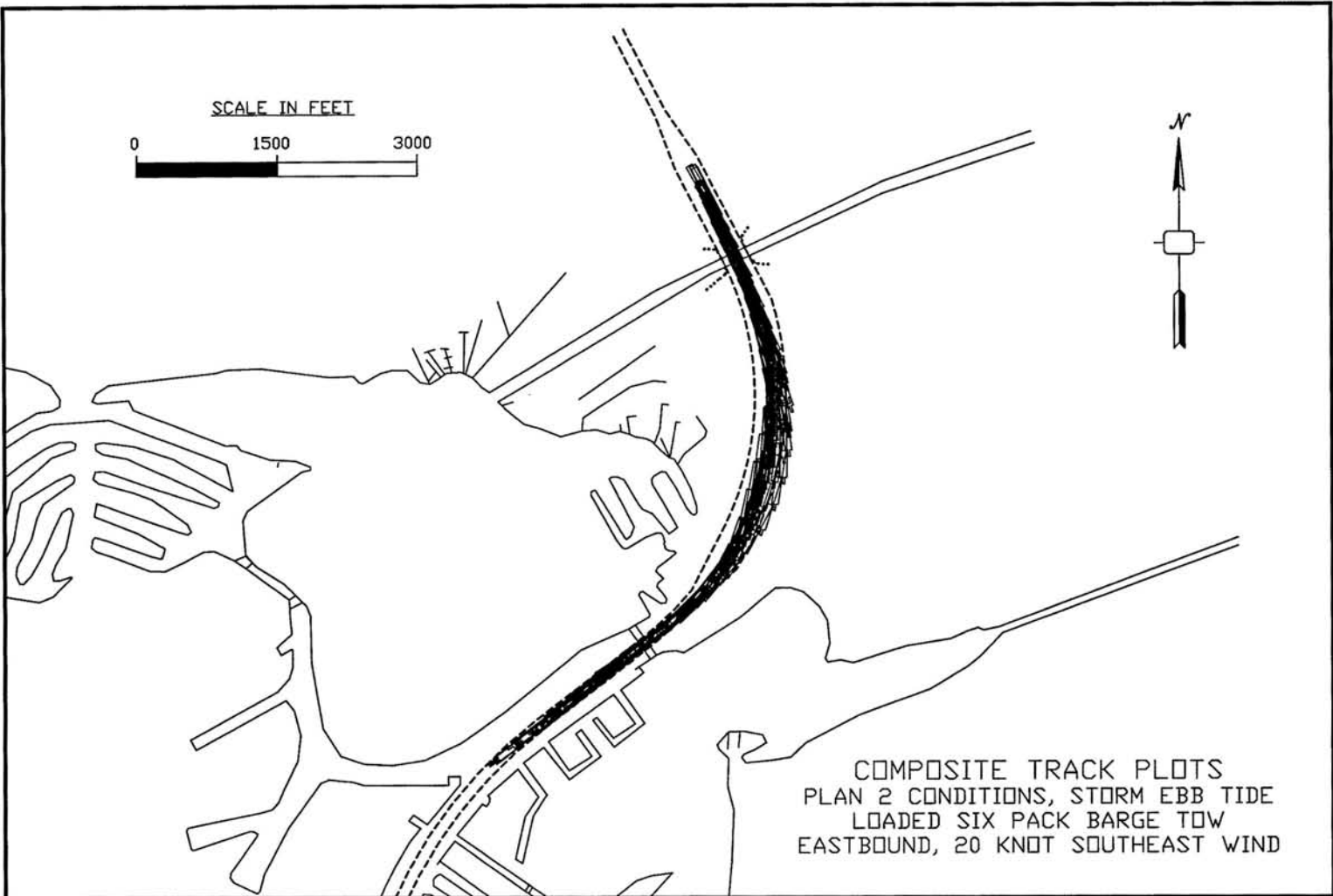


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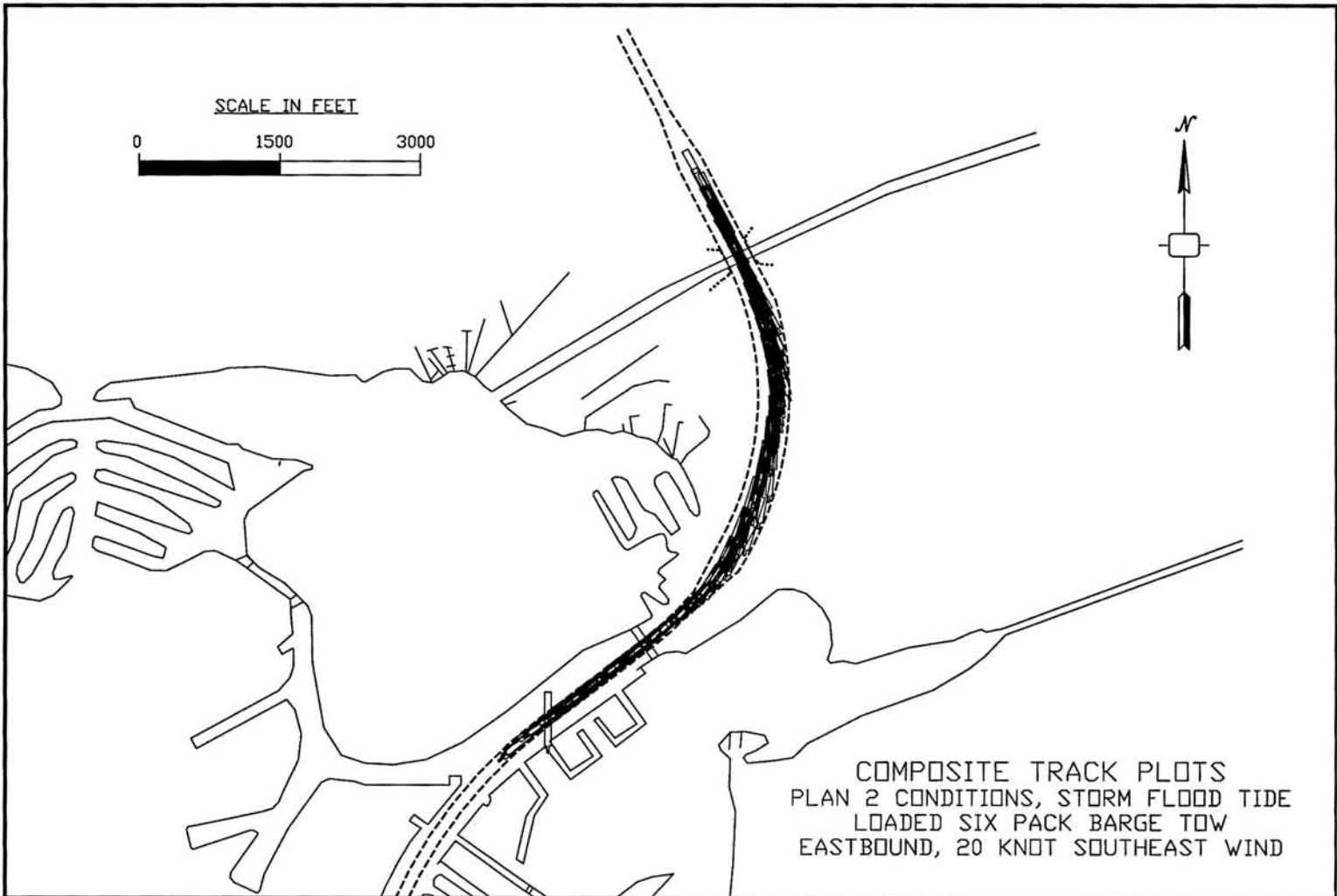


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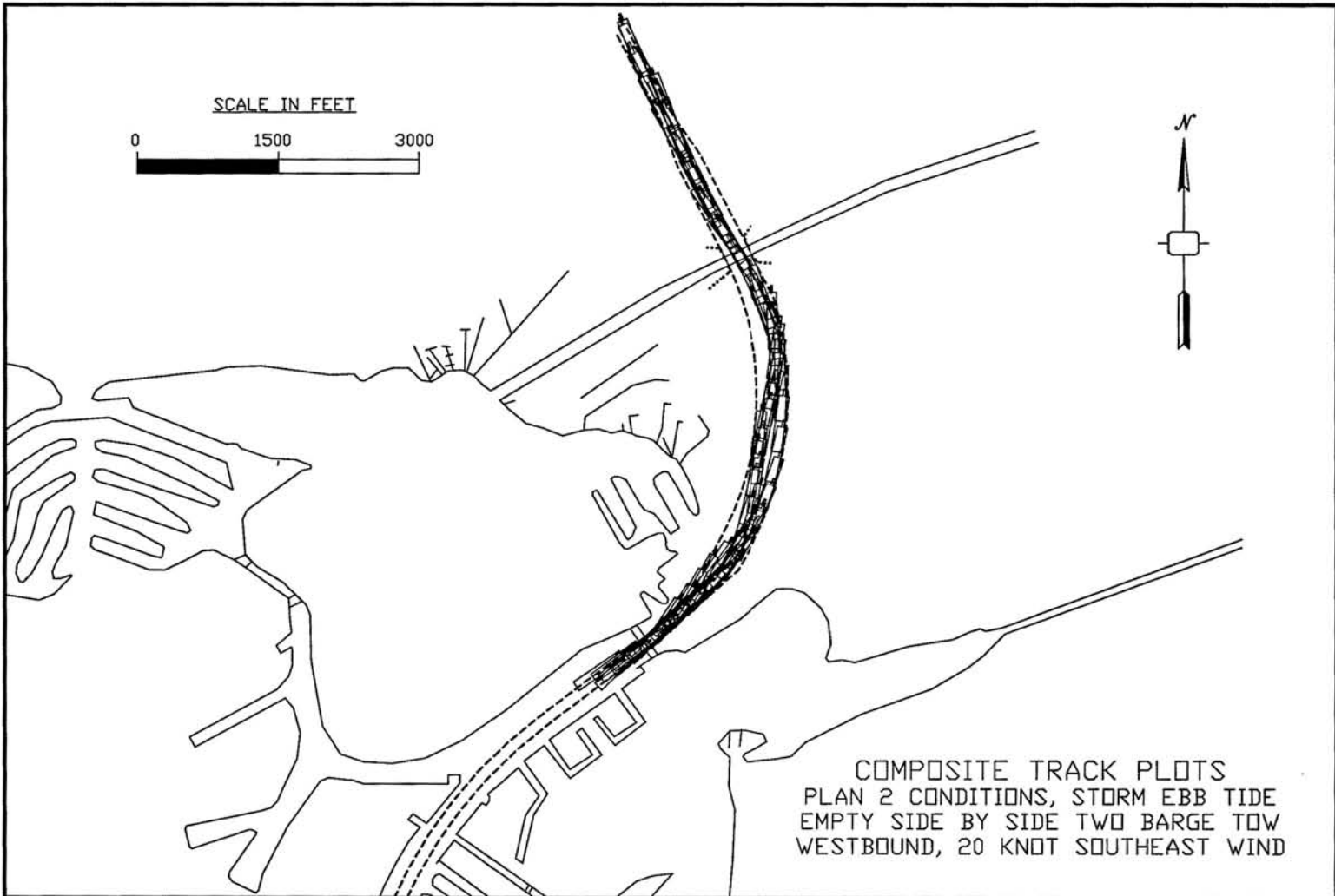


Plate 41

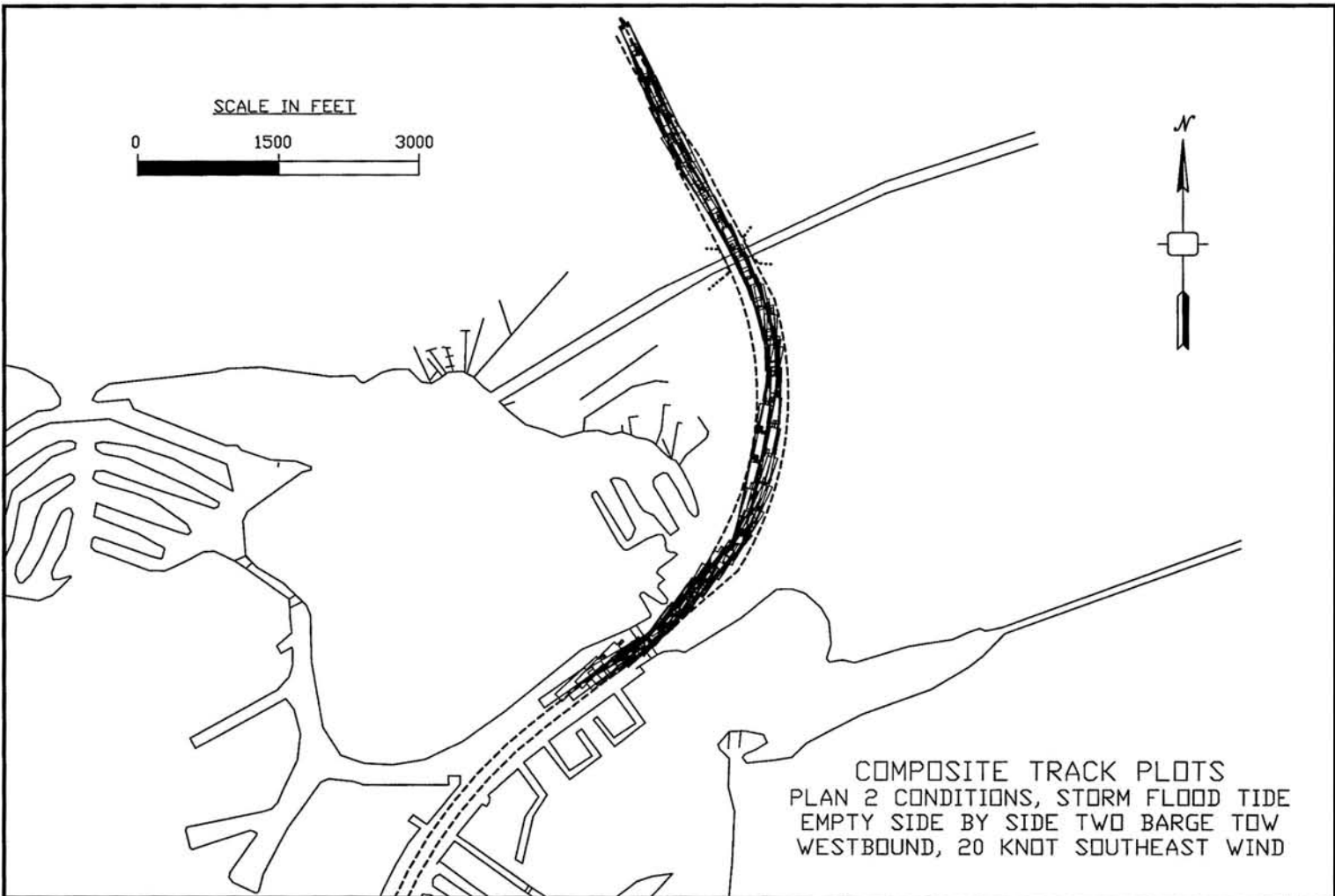


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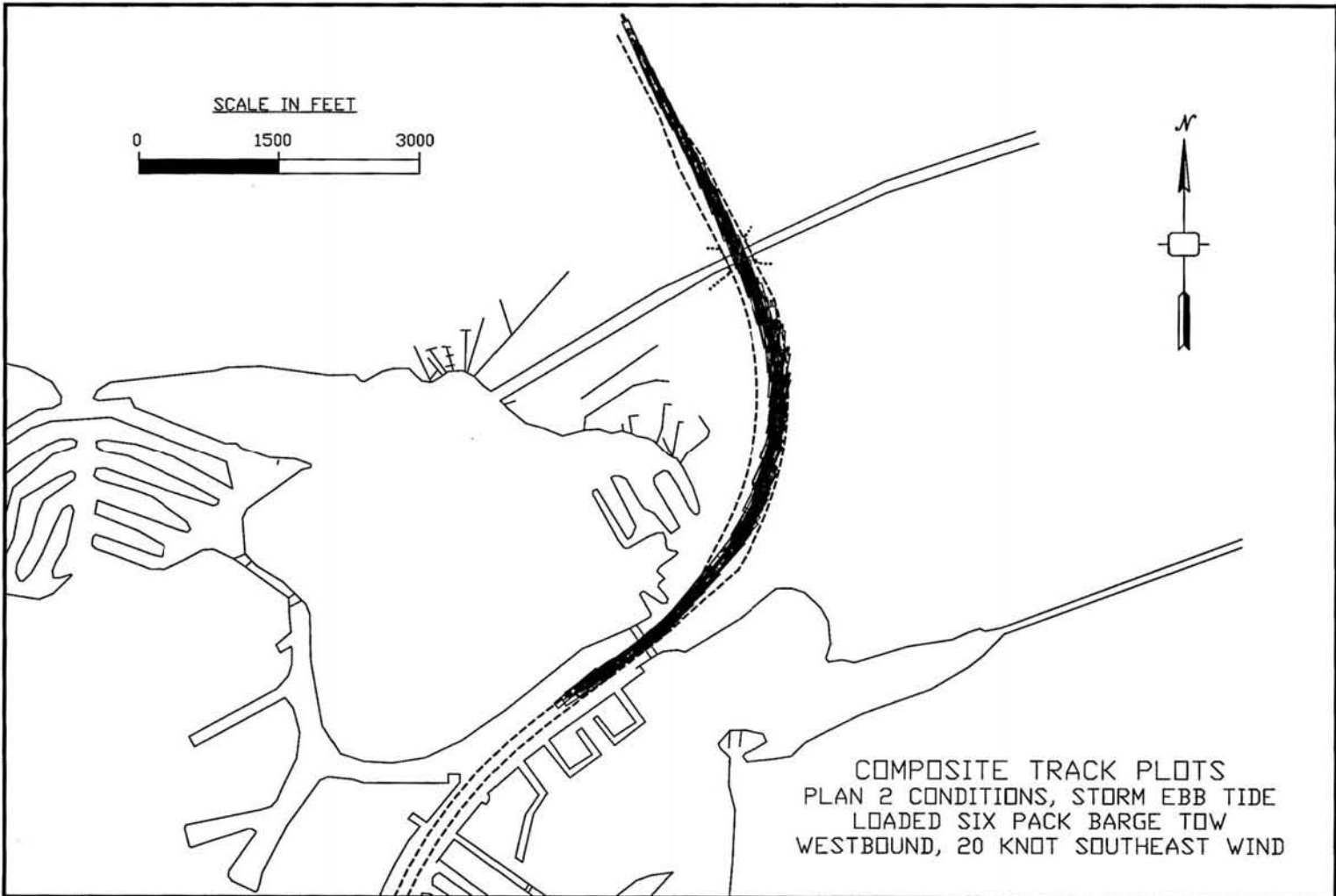


Plate 43

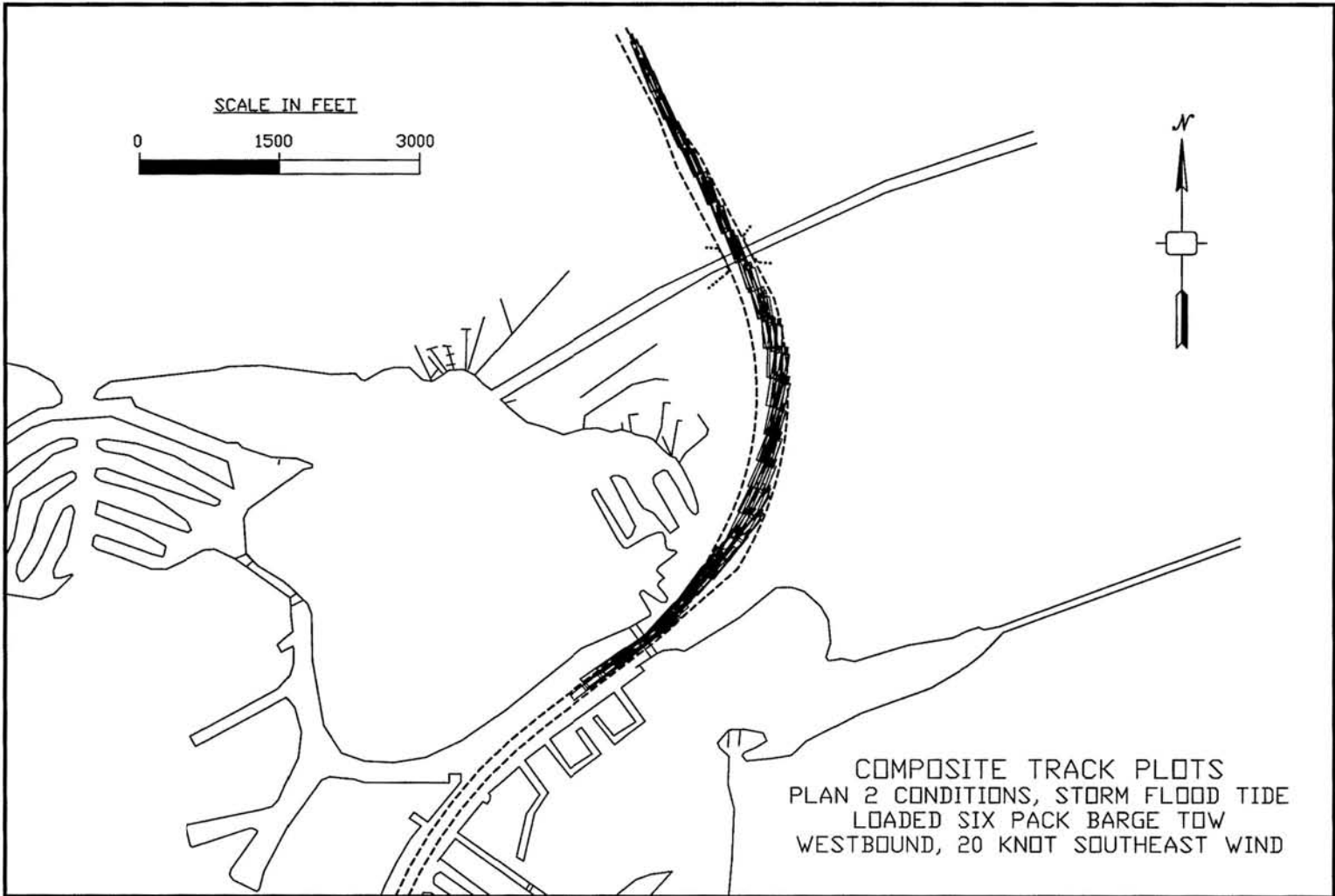


Plate 44

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				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Timothy W. Shelton, P.E. and Dennis Webb, P.E.				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
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14. ABSTRACT Laguna Madre is located on the southern shore of the state of Texas. The Gulf Intracoastal Waterway (GIWW) passes under the Queen Isabella Causeway between Port Isabel and South Padre Island. In 2001, a tow struck the Queen Isabella Causeway collapsing a span of the bridge and resulting in the death of eight motorists. In response to that event, the U.S. Army Engineer District, Galveston, (SWG) was tasked with making channel improvements that would provide for safer navigation through the Queen Isabella Causeway. To assist SWG in evaluating alternatives for the proposed channel improvements, the U. S. Army Engineer Research and Development Center (ERDC) conducted a navigation study utilizing real-time ship simulation modeling. Model development and online testing occurred at the ERDC Waterways Experiment Station (WES) in Vicksburg, MS during the period from August 2005 to May 2007.					
15. SUBJECT TERMS Accident Brownsville, TX		Causeway Laguna Madre Navigation		Port Isabel Simulation Towboat	
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